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JUNE 1941

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VOLUME 13 • NUMBER 6 • JUNE, 1941

Metals and Alloys

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Published Monthly by Reinhold Publishing Corporation, East Stroudsburg, Pa., U.S.A. Ralph Reinhold, President and Treasurer; H. Burton Lowe, Vice President and Secretary; Philip H. Hubbard, Vice President; Francis M. Turner, Vice President. Executive and Editorial Offices, 330 West 42nd Street, New York. Price 25 cents a copy. Annual Subscription: U. S., Possessions and Canada, $2.00. All Other Countries, $3.00. (Remit by New York Draft). Copyright, 1941, by Reinhold Publishing Corporation. All rights reserved. Entered as second class matter June 12, 1934, at the Post Office at East Stroudsburg, Pa., under the Act of March 3, 1879.

Articles

Induction-Hardened Cylinder Bores 713
FRED P. PETERS AND EDWIN F. CONE

A Deflectometer for Transverse Testing of Cast Iron .. 723
C. T. GREENIDGE AND E. C. KRON

Our Electric and Alloy Steel in 1940 726
EDWIN F. CONE

Electrolytic Manganese Alloyed with Copper and Nickel—I 730
B. L. AVERBACH

Forgings versus Welded Assemblies 734
J. A. PETRIE AND GEORGE W. PAPEN

Hydrogen in Steel and Cast Iron—III 737
C. A. ZAPFFE AND C. E. SIMS

A. S. T. M. Annual Convention 669
Manufacturers' Literature 702
Highlights 709
Editorial 711
News 745
Shop Notes 757
Editorial Index for Volume 13 815
Advertisers in This Issue 818
Trends 820

Metallurgical Engineering Digest

Production 764
Processing and Fabrication 775
Design and Applications 796
Testing and Control 811

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highlights

Feature Section

Pyrometry

The leading editorial deals with the qualities that are essential to a successful and efficient pyrometrist.

Hardening by Induction

The first complete metallurgical engineering article on the brilliant accomplishment of hardening the surface of the inside of cylindrical objects leads off this issue. The process, the equipment, the three major applications, the metallography, and its importance to the design engineer are discussed.

Transverse Testing of Cast Iron

Metallurgical engineers at Battelle Memorial Institute have perfected a deflectometer for measuring and recording the load-deflection curves in the transverse testing of cast iron. The new device gives a permanent record and needs only one man to operate it.

Electric and Alloy Steel

The rather spectacular advances in the American output of both electric and alloy steels in 1940 are pointed out in an analysis of statistics. Comparisons with other years are given and important trends are emphasized.

Alloys of Electrolytic Manganese

A group of extraordinarily high resistance alloys of manganese with copper and nickel are discussed as to their electrical properties. Such alloys are valuable in radio work, especially where it is desirable to pack into a small space as much electrical resistance as possible. The second part is scheduled for July.

Forging vs. Welding

Aircraft engineers will be interested in the story of how and why forged aluminum alloy fulcrum landing gear struts were substituted for those at first made of welded parts.

Hydrogen in Steel and Cast Iron

The third instalment continues the discussion of the effect of hydrogen in certain steel or cast iron parts on defects in applied coatings. This valuable article will be concluded in July.

Engineering Digests

Stainless-Clad Steel

Allegheny Ludlum's "Pluramelt" process, in which a stainless steel "armor" is melted onto a carbon steel slab or ingot by an ingenious and automatic melting and surface-alloying process, is described by Lippert (page 768).

Fluxes for Aluminum Melts

Down in a digest on fluxes for melting aluminum alloys (page 722) we find described a novel practice involving the use of "dry ice" as an effective flux.

Carburizing Stainless Steel

Experiments in carburizing stainless steels reported by Weihrich (page 778) are said to have resulted in deep, uniform, 57 Rockwell C cases with "good corrosion resistance" on 15% Cr steel.

Welding High-Strength Steels

High-strength alloy steels containing more alloy than the "low-alloy" grades are not classed as readily weldable, although weldability would appreciably increase their usefulness. Rollason & Cottrell (page 786) have a go at isolating the causes of cracks and setting up remedies.

The Designer's Dilemma

"Out of the frying pan into the fire" has been the unfortunate travelogue of many metallurgical design engineers who in recent months switched from one hard-to-get metal to one more widely available, only to have the latter go on priorities too. For "peace-time" products, the non-metals, and particularly plastics, have been the ultimate answer in many cases, as demonstrated in a table on page 796.

New Electron Microscope

The more effective and simplified 100,000-magnification electron microscope recently made by RCA (page 811) is a step away from the physicists' plaything and toward the general-industrial tool.

Eddy-Current Flaw-Inspection

The ferreting-out of defects in non-magnetic materials, such as non-ferrous alloys and austenitic steels, can now be done with eddy-current equipment that gives results analogous to magnetic tests on magnetic metals, reports Gunn (page 812).

NO PRODUCTION DELAYS—NO MAINTENANCE EXPENSE IN 10,000 HOURS AT 2050 F

Kelvinator Pleased with Dependability of G-E BRAZING FURNACE

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IN 1939 the Kelvinator Division of the Nash-Kelvinator Corporation installed a G-E roller-hearth electric furnace for copper-brazing refrigerator assemblies. The record of this furnace is interesting. It is typical of the outstanding service given by G-E furnaces.

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After 10,000 hours of operation the units were still in usable condition—proof that the heavy, hot-rolled, nickel-chromium ribbon heaters stand up under hard service.

The Kelvinator Corporation has recently installed a second roller-hearth furnace for copper-brazing—further evidence of satisfaction.

Although operating conditions in your plant may not be like those in any other factory, you can depend on G-E furnaces to give you good, economical heat treatment. Their reliable continuity of service will help you meet RUSH production schedules.

GENERAL ELECTRIC

675-23

editorial

If The Shoe Fits

In looking over the volume on "Temperature, Its Measurement and Control," recently published under the auspices of the Institute of Physics, one finds much of technical detail, applicable to specific problems of pyrometry. One 4½-page article by Dr. Sosman, on "The Education of a Pyrometrist" is a gem that could sparkle in many lights; it is applicable to the problems of education of lots of other types of "ists."

Sosman discusses the operating pyrometrist, in which the important qualities are those "he has inherited from the last three or four generations of his ancestors." "The boy who buys a $15 Ford wreck and makes it run will be the man we want." "Secondary school education, four years of Latin as good as anything." "College education, unnecessary, but desirable mainly because if a lasso is thrown into a college crowd, the chances of getting a good pyrometrist are better than if the lasso is thrown into a mass meeting in a public square."

Discussing the research pyrometrist, Sosman remarks "What the country needs is more skepticism. This is just as true in the field of pyrometry as in politics." The skeptic's most important job is to ask "How do you know that the junction is at the same temperature as the steel?" (Doyle, in another paper on "Relation of Uniform Pyrometer Records to Uniform Products," underscores the same question).

Now comes the part of wide applicability. The research man must lack one attribute, that of complacency. Eight positive attributes are listed of which the most important individual instinct is the hunting instinct, the drive that leads one to undergo all sorts of hardships for the sake of tracking down something elusive. (The listing of this gives us considerable personal satisfaction; perhaps we should enter our hours spent after birds and with bird dogs on our time card).

Among the important social instincts is cooperation, very necessary in industrial research, very weak in many otherwise good research men. Translation of new devices and new information into every day plant operation requires "ability to take into account the other man's point of view, to recognize that the operator knows some things by daily experience and observation that the research man may not even suspect, and to gain the operator's confidence and wholehearted backing." "To do this, it may be necessary to match each noncooperative investigator with an able and understanding cooperator who may not be a genius at invention or discovery, but can get things done in the plant."

Some closing sentences bring out the effects of such influences as prejudice, personal attraction and repulsion, and plant politics, factors that may completely mask the normal operation of good equipment, and there is comment on the famous, though mythical Greek, Reciprocates, who can bob up to defeat a well thought out design of a set of equipment.

Reprints of this article might well be handed out with the diplomas of graduating engineers, chemists and metallurgists, as well as physicists and pyrometrists.—H. W. G.

The Order of Judas Iscariot

There should be a special decoration, analogous to the Iron Cross, to be awarded to those in the United States who delay the defense and aid-to-Britain program. Those labor "leaders" who impose strikes for jurisdictional or dues-collecting purposes instead of keeping at work while any proper points of difference are being ironed out or, on the other hand, employers who are recalcitrant in adjusting differences and set the stage so that strikes are actually necessary, the Government officials who condoned sit down strikes and now look complacently on strikes in defense industries, and others, are all eligible.

The coal strike with the resultant coke shortage and drop in steel production and the shipyard strikes can easily be appraised in their delaying effect, but some others have a less obvious effect, for they operate to delay subcontractors rather than producers of actual armament or of what the public recognizes as essential to armament.

If there comes a shortage of armor plate steel, the steel industry will get blamed for it. Actually, the prime cause for such a shortage, if it cannot be averted by extra effort in the meantime, are all the responsible parties who tied up the Allis-Chalmers plant that was making the electrical equipment to make the ferroalloys to use in the armor plate steel. The labor leaders and those in authority who dilly-dallied for 30 days are recommended for extra large J. I. medals.

There should be two types of medals, one for those who delay the program intentionally, and the other for those who are just too dumb to see that insistence on their pet panaceas for social ills has quite the same delaying effect as if it were intentional. Between them, we respect the 5th columnist quite as much as the 4½ columnist.—H. W. G.

More than 40 Years of Research —in Every Pound of Inland Steel

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Induction-Hardened Cylinder Bores

By FRED P. PETERS and EDWIN F. CONE

Although some of the most brilliant accomplishments among recent metallurgical engineering developments have been in the field of surface-hardening, the problem of automatically producing an ultra-hard surface on cylinder bores has until now not been satisfactorily solved. The Budd induction heating process, fully described for the first time in this article, is believed to offer the engineer at last the combination of properties he has long sought for many industrial cylinder-wear applications—non-spalling internal surfaces of up to 69 Rockwell C hardness integrally combined with tough, ductile, machinable body-material, and capable of fool-proof production at high rates of speed.

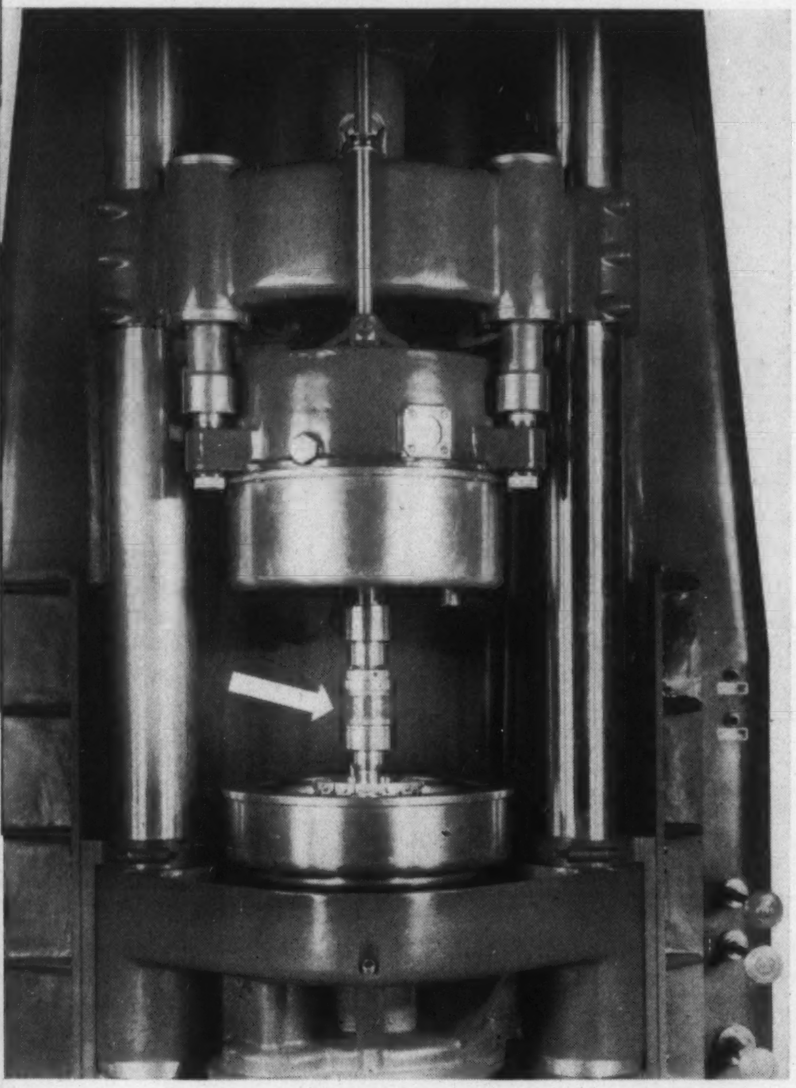
This latest and quite "different" extension of induction heating to new problems provides a striking example of the relation between metallurgical engineering design and production practice. The new process, interesting for its own sake as a process, is of still greater interest in providing a new "material" and thus permitting designs not heretofore possible. Many of these new possibilities derive from the unique physical properties and machinability of the hardened surfaces, which themselves may be traced to certain unfamiliar metallurgical characteristics possessed by the treated metal—as discussed herein.

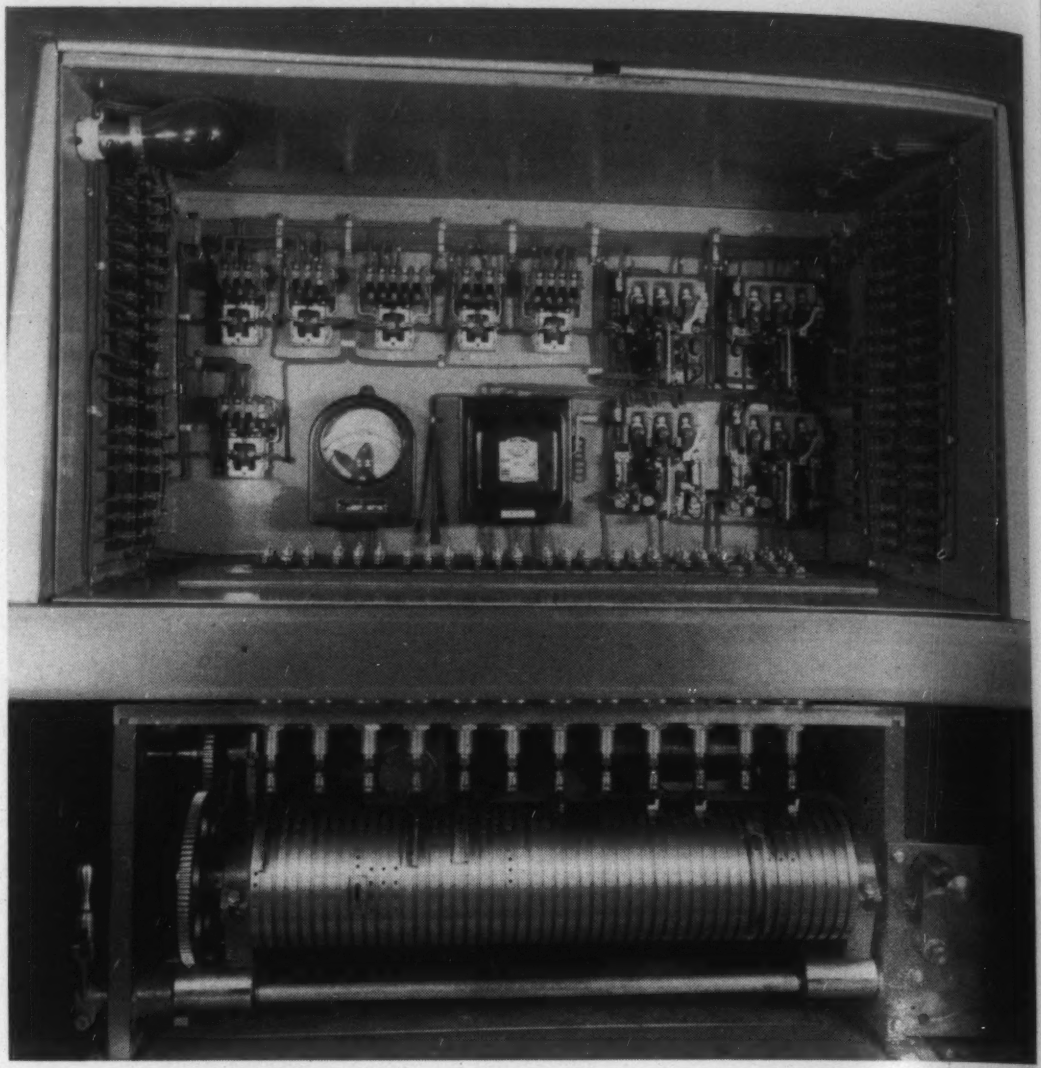
METALLURGICAL ENGINEERS HAVE BEEN extremely fortunate in the variety and utility of hard materials and surface-hardening processes that have become available to them in recent years. Hard-surfacing metals of the Stellite type, nitrided steels, cemented carbides and borides, flame-hardening, hard-chromium-plating, and induction-hardening of outer surfaces (*e.g.* the Tocco process, described in our January 1938 issue) are among the best-known of these recently developed aids to better design and manufacturing practice.

The newest addition to this field is the process for induction-hardening the *internal* surfaces of cylinders, tubes, pipes, etc., developed by Howard E. Somes of Budd Induction Heating, Inc., a subsidiary of Budd Wheel Co. of Detroit. Although akin to the foregoing developments in being a method of producing a very hard surface where required for wear resistance, the new method is none-the-less unique in several respects: It is the first commercially successful application of automatic induction-hardening to the inside surfaces of cylindrical parts—an entirely different proposition from external surface hardening; the hardnesses produced in both steel and cast iron are remarkably high, yet are accompanied by unexpected machinability, physical properties and microstructure; ultra-high integral surface hardness can thus be conferred on certain types of industrial surfaces where it has been most sorely needed—diesel engine cylinder bores, aircraft engine cylinder barrels, wheel hub interiors, hydraulic cylinder barrels, etc.; and the equipment used is actually a precision machine tool capable of turning out hardened parts on a mass-production scale.

This new process, in effect, makes available a new type of engineering material and permits new designs

The induction heating "head" and quenching device, in operating position, on a Budd machine used for internal surface-hardening cast iron cylinder liners. The liner (not shown) is held in place by chucks, one of which may be seen just below the head, while the head is drawn progressively through the bore.





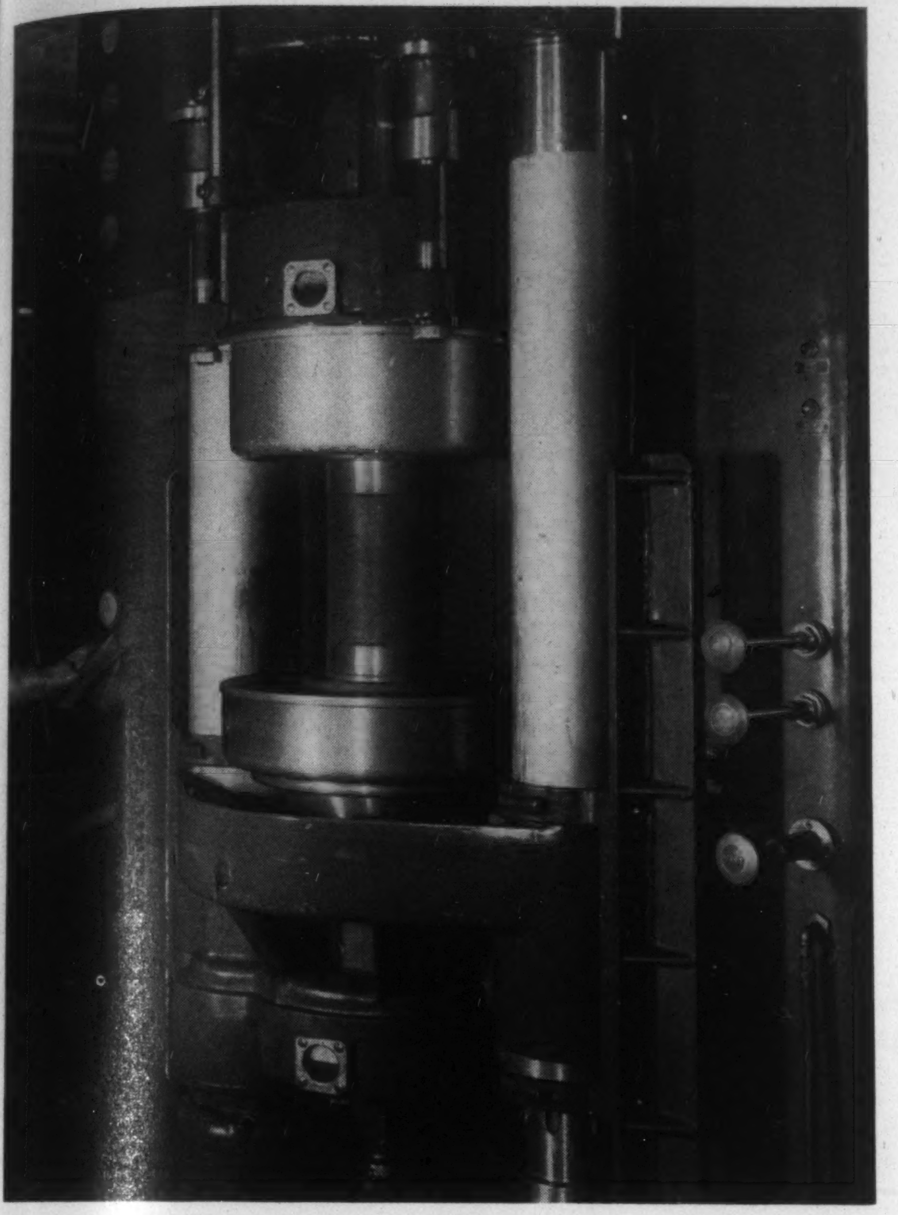
The automatic sequencing controller—actually the operating "brain" of the machine. The precision control switches are operated by cams mounted on the revolving drum in the lower part of this picture. In this case the drum receives 4 sets of cams, each set controlling the cycle for a different size of cylinder to be treated.

that are basically cheaper to produce. With it there is provided a combination of characteristics not hitherto available in any one metal—extremely high hardness (up to 69 Rockwell C), concomitant wear resistance, exceptional physicals, minimum distortion, and unexplainably adequate machinability. It will be particularly useful to engineers seeking wear resistance combined with high physicals, or for applications where it is desirable to incorporate a wear-resisting surface as an integral part of a load-bearing member. *The process is specially important today because it can turn out fully-hardened parts with the utmost rapidity, and affords a means of saving on defense-necessary alloys.*

The Process and Equipment

The fundamental purpose of the process is to develop a hard, wear-resisting surface on the inside area of a cylinder without disturbing the toughness, ductility, machinability and dimensions of the main body. A corollary objective has been the production of this condition in "ordinary" steels and irons as well as in alloyed material. Actually, the process is now doing these things in large-scale applications, and an automatically operated control system insures for each job uniformity of area treated, of depth of hardness penetration, and of hardness along the treated surface.

This "selective" hardening is accomplished through the concentration of high-power, high-frequency electromagnetic current in the surface to be hardened. In the Budd process, the high-frequency currents are caused to flow almost entirely in this shallow internal surface zone, and heating is so fast that this zone is raised to hardening temperature almost instantaneously—at least before any significant amount of heat is lost to the main body of the part. The immediate application of a controlled water quench finishes the metallurgical treatment. Close control of



A cast iron diesel cylinder sleeve in place, ready for the hardening operation.

results is obtained through accurate automatic control of the power input and frequency of the current, and of the volume, pressure and angle of direction of the water quench. The time taken for the complete heating and quenching cycle is only a few seconds.

The equipment used in the process comprises a source of high-frequency current (usually a motor-driven inductor alternator) and its metering, conducting and transmitting accessories; the hardening machine, with its heating "head," quenching fixture and work-holding device; and the all-important controller system.

For example, one generator in use on this process is hydrogen-cooled and develops a 9600-cycle current, with a capacity of 500 kilowatts at 800 volts. The generator in any case may be mounted in a position remote from the induction-hardening machine—by conducting the current to the machine with a 2-conductor lead-sheathed concentric stranded cable, power losses are no more than 1 or 2 per cent in 500 to 600 ft.

The Hardening Machine

The cable connects at the hardening apparatus with a specially-designed sliding-core switching transformer, which reduces the voltage to safe working values and also serves to switch the power on and off the heat treating head. The load is applied by moving the transformer primary into inductive relation with the secondary, which is itself connected to the heat treating head by means of a massive conducting arbor similar to the spindle of a machine tool. This arbor consists of 2 concentric copper tubes insulated from each other. The transformer is at the top of the hardening machine, with the arbor and heat head suspended from it.

For each job a suitable work-holding fixture is provided (usually on the lower part of the machine), and in some cases the part being treated is simultaneously rotated and moved axially with respect to the heating head during the treatment-cycle. In operation, it is necessary that the work-piece be chucked so as to be held in the exactly-desired relation with the head, yet not touch it.

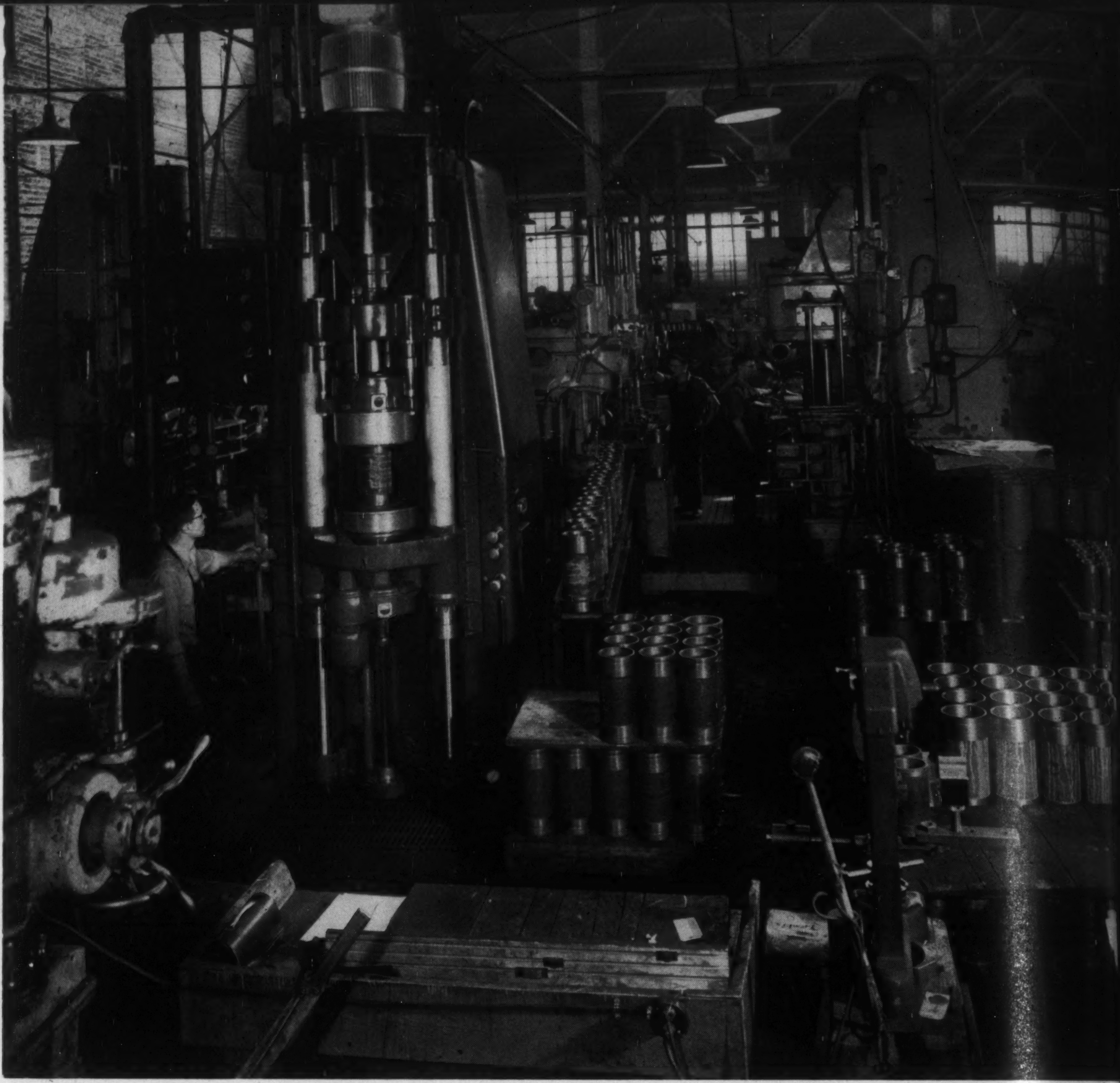
The heating head is *the* vital part of the machine. Connected with the transformer secondary, this head comprises a copper tube coiled around a laminated iron core, all on a mandrel. Cooling water is circulated through the tube, since current densities as high as 200,000 amps. per sq. in. are reached in some cases.

The quenching device operates directly under the heat head, and in controllable relation to it. It is attached to the lower section of the machine, rises toward the head during the treatment cycle, and is retracted downward during loading and unloading.

All of these critically important timed sequences are maintained by a sequencing controller made up of a series of precision cam-operated switches, with different sets of cams used for controlling different sizes of cylinders to be treated. Time-consuming change-overs from one bore size to another are thus unnecessary. The controlled movement of the work piece and the heat treating head is accomplished by a motor-driven hydraulic system, and even the coolant passing through the transformer coils is metered.

The machines are compact. Not more than 35 sq. ft. of floor space is required per unit, including "elbow room" around it. At the Budd plant, 2 of these machines are set up and operated in the production line just as any boring mill might be; no stock accumulation is required, and the machine does its job just as fast as the line delivers parts to it.

Thus—in operation—the machine is set for any desired heat treating operation within its range by a convenient adjustment of the controller and its cam-operated switches, and the proper heat head and



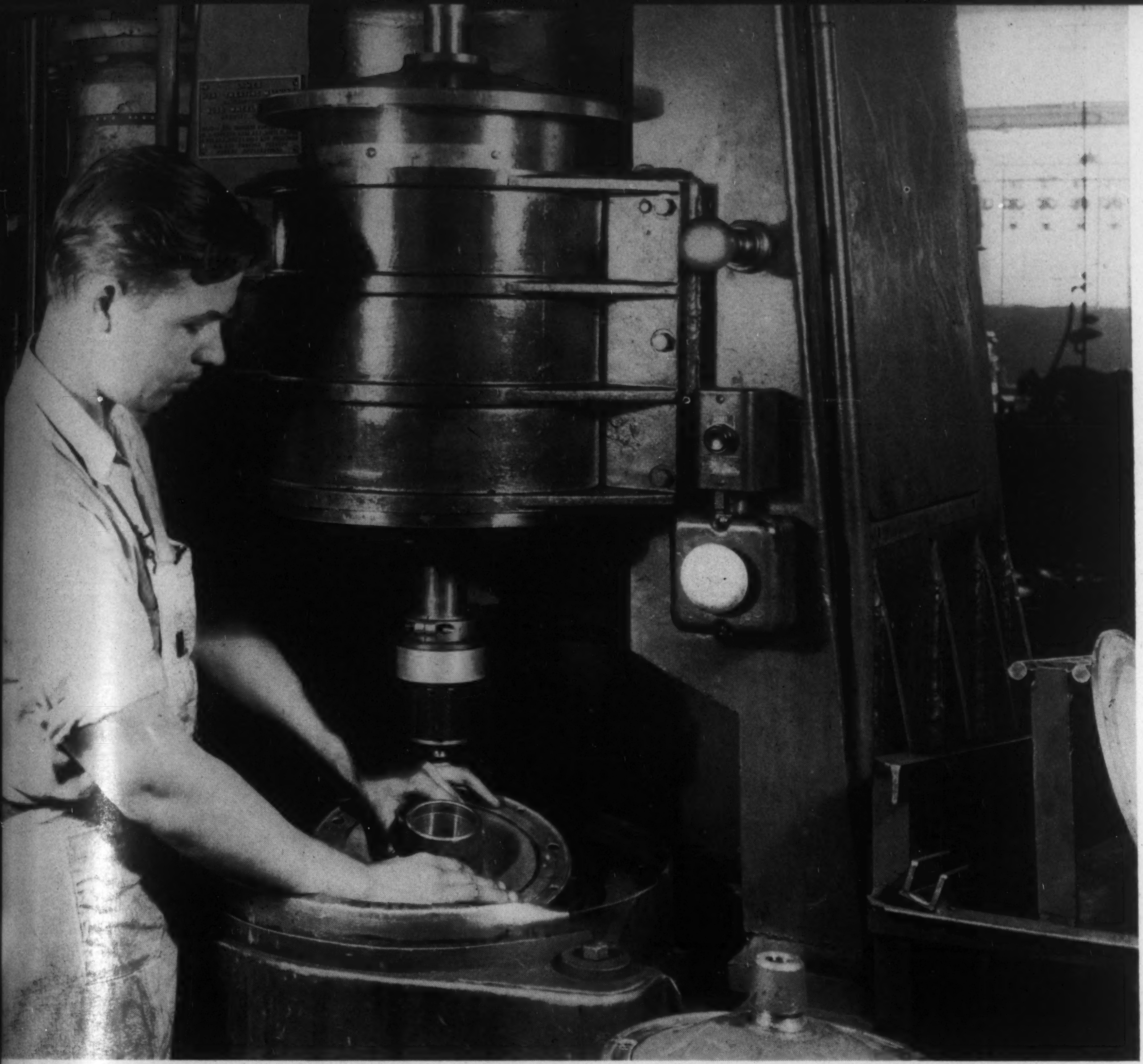
Caterpillar Tractor's installation of the Budd induction heat-treating machine used on all liners for this company's diesel engines. Note that the machine is located directly in the production line.

work-holding fixture; the latter closes and automatically raises the cylindrical work-piece so that it surrounds the heating head, with the latter (and the quench-fixture) in position at the *bottom* of the bore to be treated. The cylinder is then automatically lowered while the high-frequency current is applied, and the quench follows at the correct interval, the treatment thus being "from the bottom up." At a pre-determined moment, the quench is automatically shut off, moved away from the heating head, and the cylinder is removed. The operation—precisely reproducible for an indefinite number of repetitions—may require no more than 3 seconds for the complete cycle.

Applications

The process has already found important large-scale application for at least 3 types of products, has been regularly used on a small scale for several others, and will certainly be applied on still others that cannot be discussed because of their bearing on national defense.

The original machines were employed for hardening the internal area of forged steel automobile rear-wheel hubs so as to provide an integral roller-bearing race. Since then many new machines and process-cycles have been developed. The most notable of these later applications have been the hardening of cast iron diesel cylinder liners for tractors and the hardening of steel aircraft-engine cylinder barrels. All of these will be described in subsequent paragraphs. In addition, the method is being used for hardening the bores of hydraulic cylinders and of



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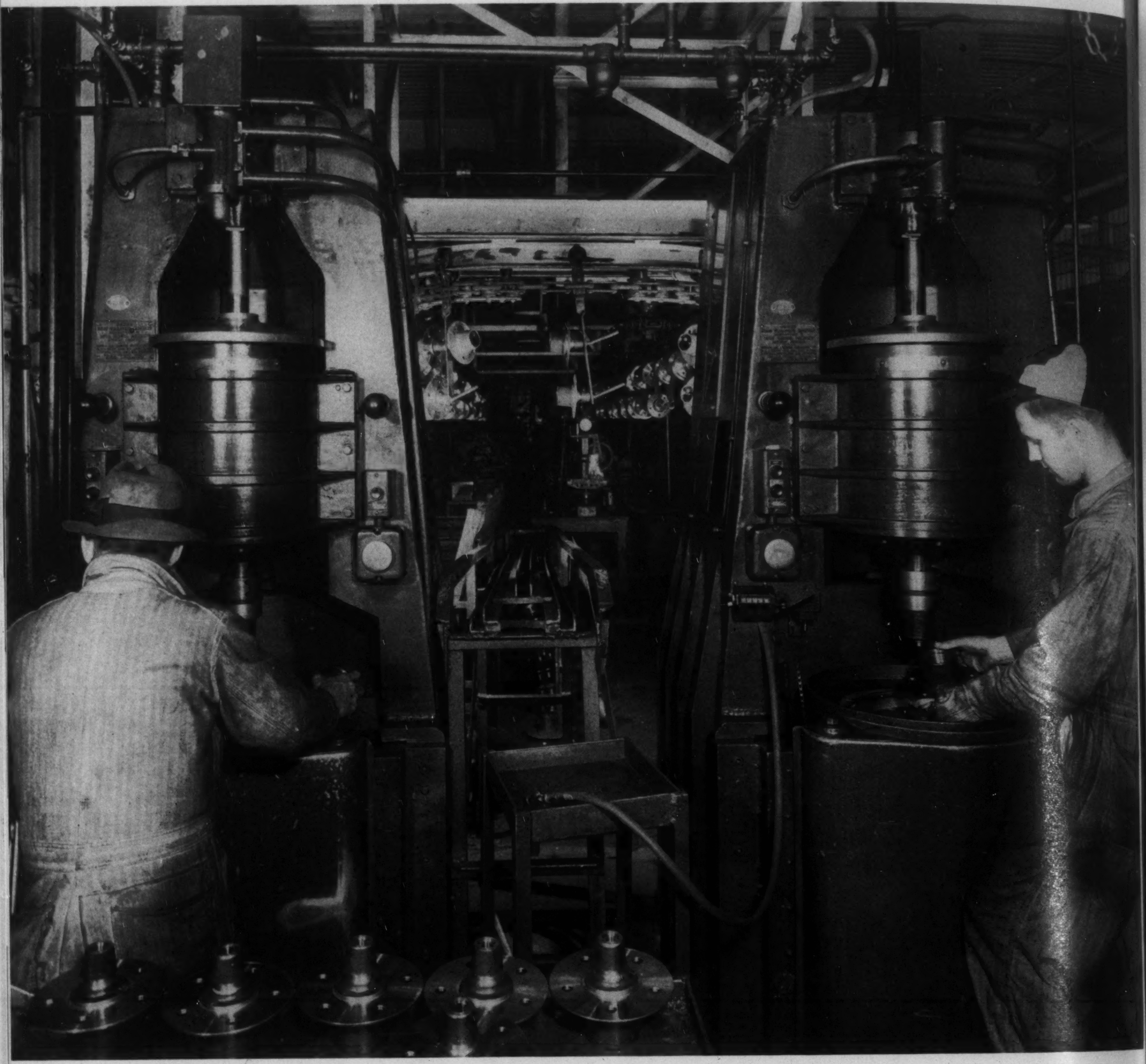
Another application—hardening the inner surface of automobile wheel hubs to form an integral bearing race. Here the operator is placing the hub in the machine, after which the induction heating "head," visible just above the bore, will be lowered automatically and the bearing race heated and quenched.

slush-pump cylinder liners for pumping colloidal mud in oil-well drilling, as well as for heat treating oil-well casings to increase joint strengths.

In each of these instances the new method has demonstrated its superiority over the established design or production practice for the product in question—flame-hardening in one case, over-all heat treatment and localized quench in another, nitrided alloy steel in a third, hard-surfaced layers in a fourth, and so on. Yet the new process is far from a cure-all and is not claimed to be the general answer to run-of-the-mill surface-hardening problems; replacement of an older method or design has always been on a basis of quality and serviceability for the particular application involved—usually cylinders and bores that need high hardness backed up by *unusual* physical properties.

In all the applications the convenient machining practice made possible with the new method has been a large factor in its selection. Thus, where design permits, the outside surface or body of the unit can be machined *after* hardening the bore. One new possibility is the practice of composite heat treatment—hardening a bore after the cylinder has been heat treated throughout and machined to finished dimensions. But the most remarkable feature from the machining standpoint is the fact that internal surfaces hardened to 66-69 Rockwell C by this process can themselves be milled or drilled, if necessary, by using carefully worked-out machining techniques.



Two of the heat treating machines in operation on auto wheel hubs in Budd's production line at Detroit. Each is capable of hardening the bores of 180 hubs per hour.

Aircraft Engine Cylinder Barrels

The most recent and one of the most promising of the applications of the Budd process, from the general viewpoint, is its use for hardening the bores of aircraft engine cylinder barrels. At the present time, cylinder barrels of forged S.A.E. 4145 steel (1% Cr, 0.20 Mo) are being regularly hardened by this method for a leading engine manufacturer, with eminently satisfactory results. The case produced is more durable, deeper and more uniform concentrically than the nitrided case previously used, and since there is no composition change in the treatment, the hardened surface does not flake off. Production rates are remarkably high.

In fact, according to Budd engineers, the wide application of this process for aircraft engine cylinder barrels could solve one of our most serious bottlenecks in airplane production. Rates of production as high as 500 hardened cylinder barrels a day per machine could be achieved almost immediately, and the use of highly alloyed steels to develop top hardness could be dispensed with; even S.A.E. 1040 steel can be hardened to a sufficiently high value by this process to serve for modern aircraft engine cylinder barrels.

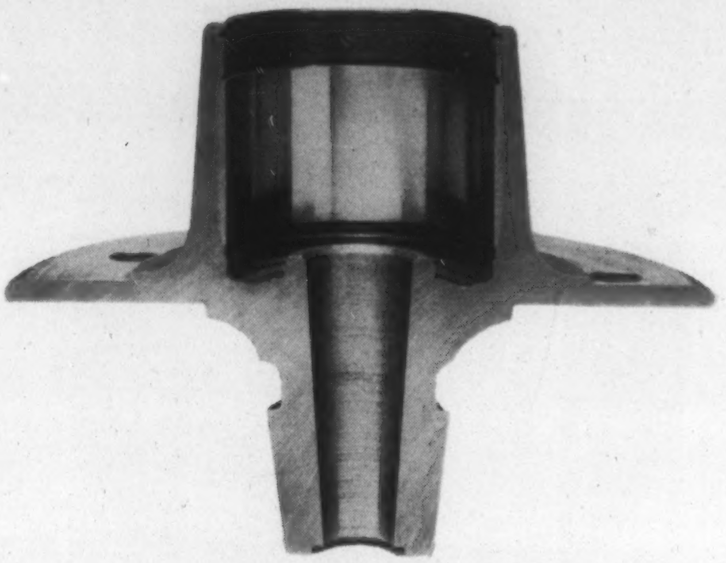
In the application mentioned, the rough-machined forging is first "core-hardened" — heat treated throughout by oil quenching and tempering—to, say, 32 Rockwell C. Then the cylinder is bored and the bore is rough-honed to a few thousandths of an inch under finished size. The outside surface is then turned concentric with the inside and the ends are faced to length.

At this point the bore is induction-hardened in a Budd machine to 62-64 Rockwell C, the depth of hardness being accurately pre-set at about 0.045-0.050 in. After hardening, the bore is finish-machined, the outer surfaces are semi-finished and the bore is honed. Distortion in this treatment is so slight that only 0.004 in. to 0.007 in. honing is required—usually just enough to remove tool marks.

Cast Iron Cylinder Liners

Probably the broadest type of possible application for the new process is its use for hardening the internal surfaces of cast iron cylinder sleeves. Ultrahigh hardnesses combined with practical machinability—all in an inexpensive material with some pretty good inherent "core" properties of its own—are obtained.

At the plant of the Caterpillar Tractor Co., in Peoria, Ill., *all* cylinder liners for Caterpillar diesels are now being treated by this process. The liners range in size from 3¾ to 5¾ in I.D. and 10 to 15 in. long; all are treated in the same machine, which is installed directly in the liner production line. The machine hardens the bore surfaces to the equivalent of 60-66 Rockwell C, and these are subsequently tempered to somewhat lower values. The depth of the hardened zone is about 0.070 in.



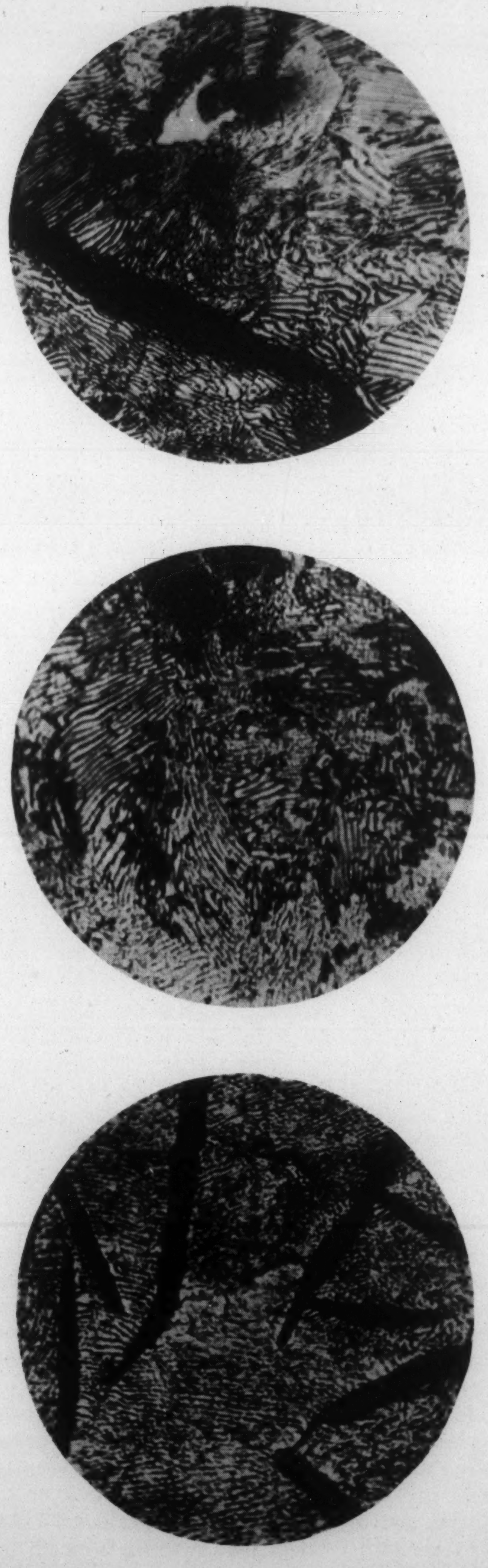
A cross-section view of the Budd-treated auto hub, with the light-colored hardened area plainly visible. Note the clear transition between the hardened zone and the unaffected body of the hub.

Production rates on one machine are regularly between 75 and 105 hardened sleeves per hr., depending on their size. After Budd-hardening and tempering the bores move along the production line, are honed to the final finish before "surfiding," and the outside surfaces are finish-turned for subsequent insertion in the diesel cylinder blocks.

The hardened surfaces of these liners are machinable with special techniques. Caterpillar is actually doing 4 milling operations through the hardened zone—milling 2 valve clearance pockets and 2 rod clearances, and thinking nothing of it, even though the surface hardnesses are such as to make the average machinist exclaim "It can't be machined!" (The metallurgical factors that lie behind the "different" machining properties of Budd-treated metal are discussed later in this article.) Also, the distortion introduced by the treatment is so slight that on the surface itself only honing (no grinding) is required for finishing.

The finished sleeves are extremely hard, yet not in the least brittle. They are declared by Caterpillar engineers to be superior in wear-resistance and durability, physical properties and uniformity to those previously produced by furnace heating followed by oil-quenching and tempering. In addition, the new process provides automatic control, production-line adaptability, and production rates far in excess of those formerly reached.

Most of these liners are made from a good grade of plain or low-alloy cast iron, cupola iron being entirely satisfactory. A typical iron for this purpose would run 2.80 to 3.10 per cent total C, 0.60 to 0.80 per cent combined C, ½ to 1 per cent Ni, ¼ to ½ per cent Cr, and have a tensile strength of



Typical microstructures in Budd-hardened cast iron cylinder sleeves (the iron is 3.28 T.C., 0.63 C.C., 2.24 Si, 0.68 Ni, 0.58% Cr). Top—the unhardened zone, a characteristic cast iron structure of graphite plates and phosphide eutectic in a matrix of lamellar pearlite. Middle—the "transition" region, showing partial grain refinement. Bottom—the full-treated zone, with its uniform, fine grain and unexpected lamellar structure. All micros at 1500 magnifications.

45,000 to 65,000 lbs. per sq. in. Close-grained irons should be used, and for thin-walled cylinders the quality of the iron should be chosen with especial care. (The microstructures of the treated irons will be discussed subsequently.) With a good grade of iron and the correct hardening conditions as governed by the controller, cast iron becomes endowed in the zone treated with the wearing qualities of a fine steel.

An interesting side-feature of this process as applied to the hardening of cast iron cylinders is its simultaneous use as an additional inspection. Where the part being treated is porous or cracked, an abnormality of the heating current occurs within the piece and manifests itself by a melting of the surface or wall adjoining the defect; in the case of porosity marked signs of over-heating can be observed. Consequently, defective stock can be easily identified—in fact, defects otherwise discernible only by Magnafluxing or microscopic inspection are readily revealed in this way. Although defects in steel cylinders are also revealed during Budd-hardening, this inspection phase is particularly applicable to cast iron treatment.

Automobile Rear Hubs

The first successful large-scale application of the Budd-hardening process was for hardening the inside surface of rear-wheel hubs for a leading automobile manufacturer. The hubs are of S.A.E. 1045 steel forgings, and the bore is hardened to provide an integral race for roller bearings. To date, over 5 million of these Budd-hardened hubs have been placed in service without a failure being reported.

The operation as carried out on a truly mass-production scale at the Budd plant is typical of the results that can be expected when using the process on plain carbon steel parts. The complete cycle requires 20 sec., and production is normally 180 hubs per hr. per machine, although the machines can be timed to operate as fast as 240 parts per hr., if a plant should ever need them that fast.

For this particular application, hardness tolerances are broad (specifications are 56 to 64 Rockwell C) yet the Budd machine turns out hubs consistently with hardnesses between 60 and 62 Rockwell C. The depth of hardness is about 0.10 in. The wearing characteristics of such induction-hardened bearing races are striking indeed—side-by-side tests have shown that a Budd-hardened race of S.A.E. 1045 steel at 62 Rockwell C excels in performance a carburized S.A.E. 4615 surface.

The machining practice associated with this hardening operation is unusually interesting. From the illustration it can be seen that the body is irregular in shape, and consists of the hub bore to receive the roller bearing, an adjacent flange for mounting the wheel and the drum, and a tapered bored stem for the axle. All boring and turning is done before induction hardening. The hub bore is hardened, and then the bearing bore is ground (actually to remove tool marks) and finished by honing.

The illustrations show the uniformity and concentricity of the hardened zone on these hubs. Owing to its higher homogeneity, steel surfaces develop higher hardnesses (as measured by the Rockwell superficial tester, for example) in the treatment than do those of cast iron. Steel parts have been readily hardened to 69 Rockwell C and in depths from 0.025 in. to 3/8 in., and certain special cast steels have even been treated to hardnesses up to 78 Rockwell C.

Metallurgical Considerations

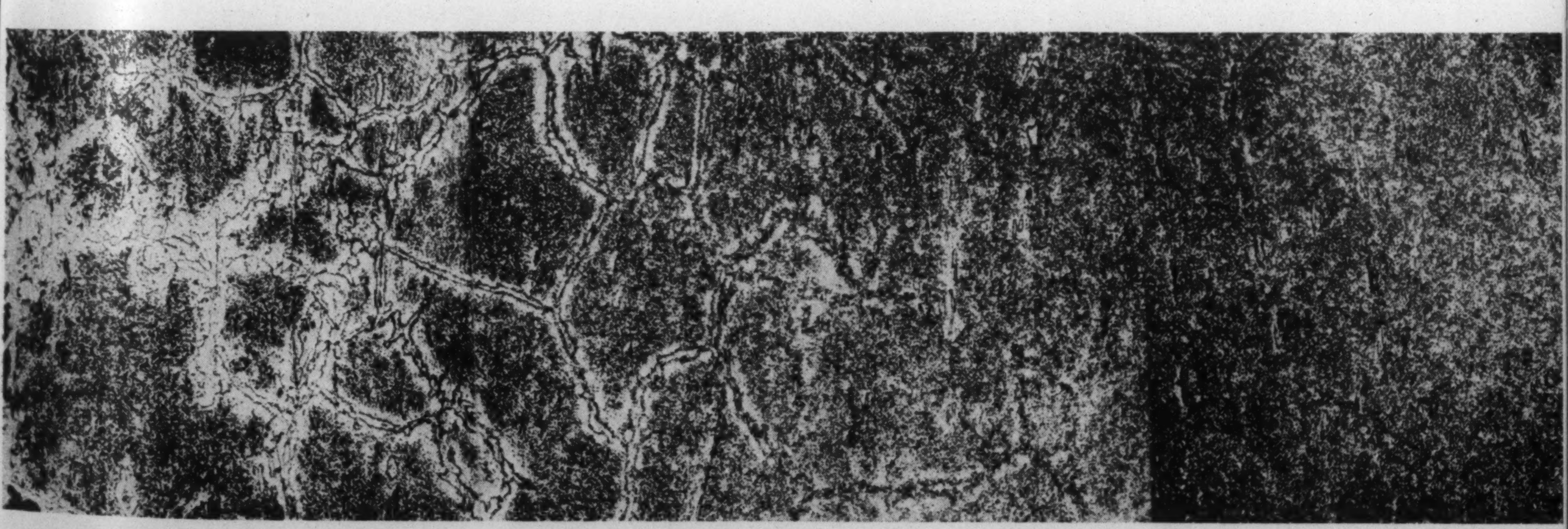
From all of the foregoing, it is evident that the process must be metallurgically "different" from more familiar hardening methods, since so many of the product's characteristics that are microstructural in origin are unique. In addition to the unusually high hardness and physical properties obtainable with a given composition, there must be cited the fact that Budd-hardened surfaces are machinable beyond the limits to which other, equally hard, materials are subject. Another interesting feature is an evidently different reflectivity of tooled surfaces that have been treated by the process; it is this that makes possible clear and prominent delineation of the depth of hardness in a cross-section without metallographic polishing and etching—as in the illustration of the hub cross-section.

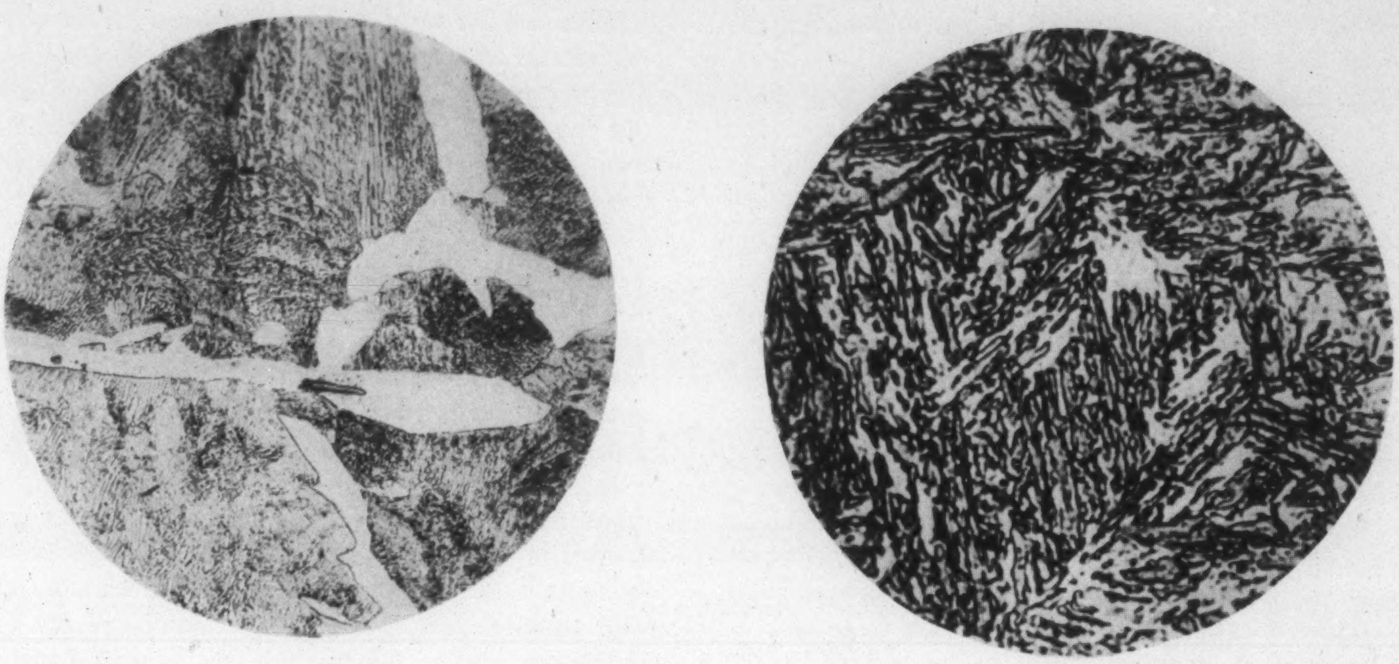
These points undoubtedly have their origin in the microstructures resulting from the new treatment. The extremely rapid quenching produces in both cast iron and steel a much finer-grained martensite than is ordinarily obtained by other methods. Distortion is held to a minimum because only a portion of the piece is heated to critical temperatures. Absence of scaling, spalling, grinding checks and cracks, and of relief of hardening stresses during subsequent machining or grinding, and, in many cases, the obviating of pre-annealing or pre-normalizing treatments, all stem from the unusual speed of heating and uniformity of structure.

In all cases the grain is ultra-refined, ordinarily there remaining no vestige of the original grain boundaries. In cast irons the uncombined carbon seems to be recombined at a greatly accelerated rate with attendant increase in hardenability and strength of the area treated. One of the most startling feaures is the lamellar structures that are found throughout the hardened portions of originally pearlitic irons. The lamellae are scarcely visible at ordinary (100-500 X) magnifications, but at 1500 X they closely resemble pearlite in iron at about 500 X.

We are indebted to L. R. Jackson of Battelle Memorial Institute, who has had considerable opportunity to examine the Budd-hardened structures metallographically, for the following information on microstructures. His comments throw considerable light on the reasons for some of the unique and

The structure of the automotive hub (a 0.37 C, 0.77 Mn, 0.025 P, 0.120 S, 0.15 per cent Si, steel forging) is shown in this matched strip continuous picture, at 100 magnifications, from the unhardened metal at the left through the hardened zone to the bearing race surface at the right. Note the complete elimination of the ferrite grain boundaries and the uniform structure in the hardened zone.





Some of the steel hub microstructures at higher magnifications. Left, the unhardened zone at 500X, showing the typical forging structure of coarse grains of pearlite bounded by ferrite. Right, the fully-hardened zone at 2000X, revealing a very fine-grained martensite together with small particles of retained austenite.

superlative characteristics of iron and steel treated by this process.

In spite of the high hardness (60-66 Rockwell C) of the cast iron cylinder liners there is a considerable amount of retained austenite in the hardened zone. The austenite is evident to X-rays and to magnetic analysis, but does not show up under the microscope in a recognizable form; it must therefore be ultra-fine-grained and dispersed throughout the structure. Austenite contents of 30 per cent and above have been observed. It is possible that the presence of the austenite is a factor in the existence of machinability at such high hardness. The combination of retained austenite and high hardness may also contribute to the wear resistance of the surfaces.

The hardened zone in 0.40 per cent carbon steels (S.A.E. 1040, 3140, 4140, and 3340, etc.) that have been examined also shows the presence of more austenite than would be expected from a more conventional heat and quench. Amounts around 10 per cent have been observed.

The induction heat treating of steel or cast iron involves heating times from a fraction of a second to a few seconds. From the viewpoint of the old rule of thumb "soak an hour per inch of cross section" the results obtained with this internal induction heat treatment seem incredible. However, Jackson points out, we can safely assume that the temperatures attained in the Budd treatment are 300 or 400 deg. F. higher than the usual austenizing treatments, and therefore need make no special assumption about the diffusion coefficient for carbon in order to explain the results obtained.

Apparently the induction heating takes the affected zone to a temperature so high that diffusion is rapid, yet the time at temperature is so short that the excessive grain-coarsening that would ordinarily be expected to accompany such high temperature heating does not occur.

Conclusion

Whatever the reasons, however, observation of the Budd process for induction hardening of cylinder interiors and of the service results it provides, makes altogether clear its position as an established commercial success with considerable still unexploited potentialities. The machine and process, by permitting the fabrication of machine parts of maximum wear resistance without sacrifice of physical properties, present the metallurgical design engineer with a new type of material for his cylinder bore applications and will be a step toward new designs and new products.

The sizes and lengths discussed in the article are in no sense restrictive, either, for machines already built handle lengths from a fraction of an inch up to several feet—and existing designs contemplate unlimited lengths! The new *internal-heating* process constitutes an ideal complement to the well-known systems for *external* surface-hardening by induction, extending the industrial applications of induction-heating to fields where it has been most sorely needed.

A Deflectometer for Transverse Testing of Cast Iron

by C. T. GREENIDGE and E. C. KRON

Metallurgists, Battelle Memorial Institute, Columbus, Ohio

In applying the transverse test for cast iron to the control of foundry operations, it is sometimes desirable to plot load-deflection curves. This involves the determination of deflections at various loads—a tedious and time-consuming operation for which two men are necessary. If several hundred transverse bars are tested, plotting of the curves is a task of large proportions.

Realizing that an inexpensive method of obtaining autographic transverse load-deflection curves would be highly desirable, the authors present a solution of the problem—a deflectometer. This new device gives a permanent record and needs only one man to make the test. A full description is here available.

—The Editors.

THE TRANSVERSE TEST IS WIDELY USED for foundry control of the strength of cast irons and in some instances for specification purposes. In this test, a cast bar is supported on knife edges or rollers, and is broken by a load applied midway between the supports. The load on the bar and the deflection midway between the supports at the instant the bar breaks are usually recorded. In addition, it is often desirable to plot load-deflection curves in order that resilience and relative modulus of elasticity may be determined. To plot load-deflection curves one must, of course, determine the deflections at various loads. This is a tedious and time-consuming operation, requiring two men. The further work of plotting the curves makes it a sizeable task to test several hundred transverse bars. An inexpensive method for obtaining autographic transverse load-deflection curves would be useful. One solution to the problem is presented below.

The wedge principle, previously employed by Kenyon and Burns[1], was applied to this case. The movement of a wedge, which is some multiple of the movement of the two halves of an extensometer, offers a simple means of measuring and multiplying the movement of the extensometer in the same operation. A schematic drawing of the deflectometer and arrangement used for measuring deflection are shown in Fig. 1.

Description of the Deflectometer

The deflectometer itself consists essentially of a tube through which a rod slides. One shoe is fastened to the sliding rod and a second to the tube itself. Each shoe has two grooves in which the two wedges slide. The operation of the deflectometer and the recording drum may be followed by reference to Fig. 1. The transverse bar rests upon the two supports attached to the moving head of the testing machine, and the rod of the deflectometer is held against the underside of the bar by a spring so that, at the start of the test, the various parts are in the position shown in Fig. 2. As the head of the testing machine moves upward, the transverse bar is gradually bent until it breaks.

During the bending the central rod of the deflectometer, which is in contact with the under side of the transverse bar, remains stationary and the tube moves upward. The shoes attached to the central rod and the one fastened to the tube move apart. The two wedges that slide in the shoes move in a horizontal direction as the shoes move apart because of the horizontal pull exerted on them by the fish lines on which weights A and B hang. Weight A is fastened to one wedge by a fish line and rubber band. Because of the tension in the rubber band, this wedge follows the rapid movement of the shoes when the transverse bar breaks and thus prevents undue nicking of the other wedge which is attached to the recording drum. The nick-

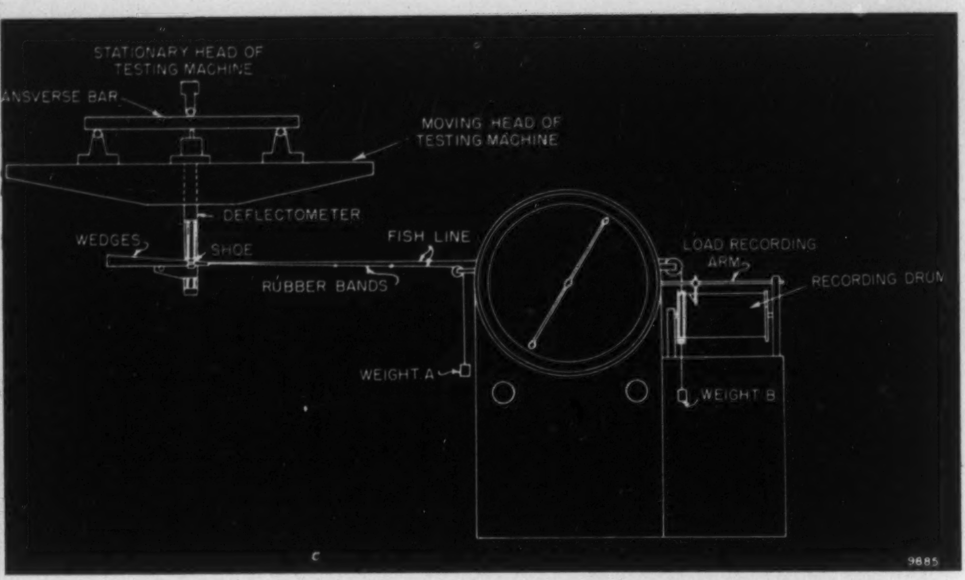

STATIONARY HEAD OF TESTING MACHINE
ANSVERSE BAR
MOVING HEAD OF TESTING MACHINE
DEFLECTOMETER
WEDGES
SHOE
FISH LINE
RUBBER BANDS
LOAD RECORDING ARM
RECORDING DRUM
WEIGHT A
WEIGHT B
9885

Fig. 1. Set-up for transverse bar testing with deflectometer.

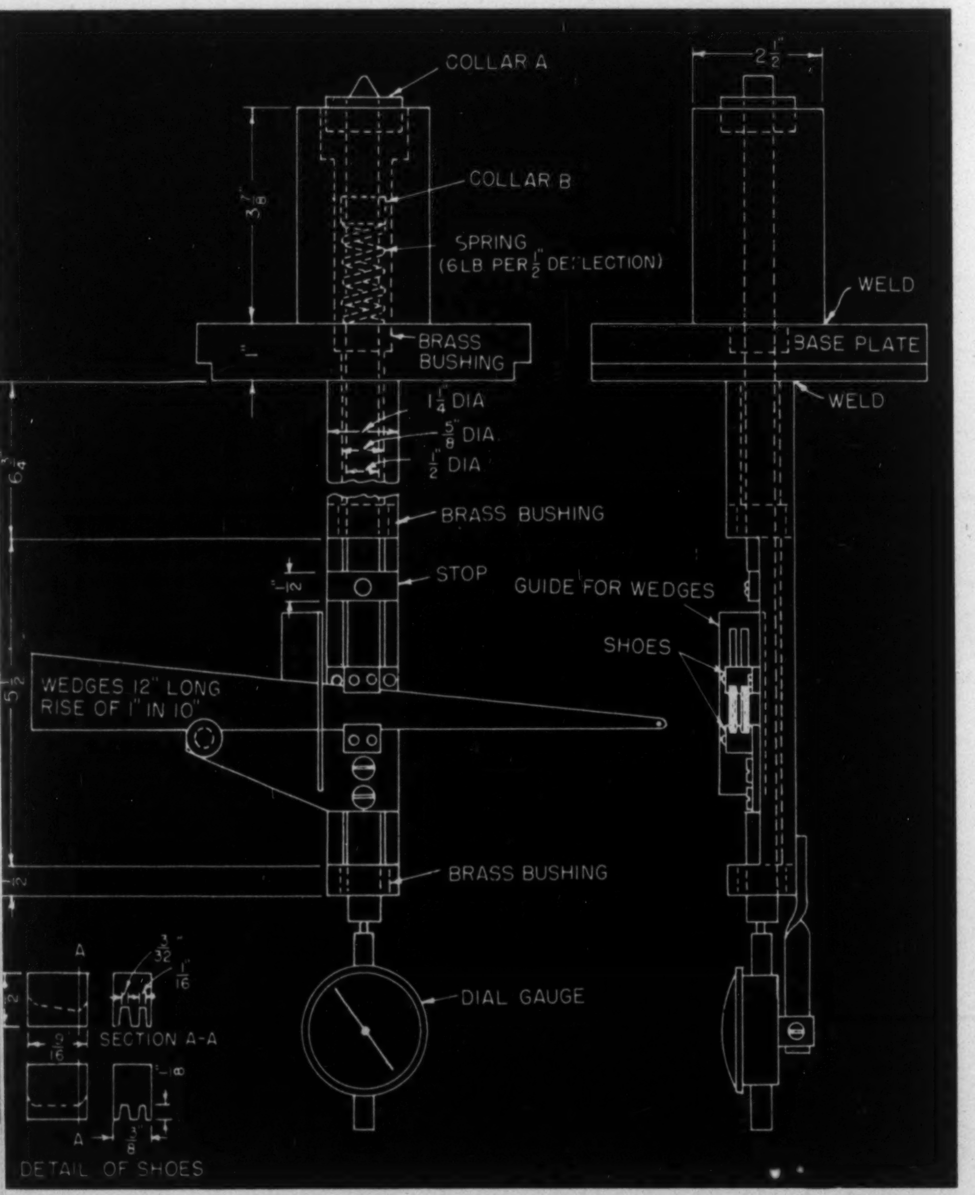

COLLAR A
COLLAR B
SPRING (6LB PER $\frac{1}{2}$" DEFLECTION)
$3\frac{7}{8}$"
$2\frac{1}{2}$"
WELD
BASE PLATE
WELD
BRASS BUSHING
$1\frac{1}{4}$" DIA
$\frac{5}{8}$" DIA
$\frac{1}{2}$" DIA
$6\frac{3}{4}$"
BRASS BUSHING
STOP
$\frac{1}{2}$"
GUIDE FOR WEDGES
SHOES
$5\frac{1}{2}$"
WEDGES 12" LONG RISE OF 1" IN 10"
BRASS BUSHING
DIAL GAUGE
A
$\frac{3}{32}$"
$\frac{1}{16}$"
$\frac{9}{16}$"
SECTION A-A
$\frac{1}{8}$"
$\frac{3}{8}$"
DETAIL OF SHOES

Fig. 2. Construction of wedge deflectometer.

ing of the wedges is very slight and is caused by the recoil action of the spring in the deflectometer.

The wedge used for recording the deflection is pulled between the shoes by the fish line wrapped around the recording drum and on which weight B is suspended. Consequently, when the wedge moves, the drum rotates, and since the wedge has a rise of 1 in. in 10 in., the linear movement of the recording drum is 10 times the deflection of the bar. The load-recording arm geared to the dial of the testing machine moves outward as the load increases. The combined movement of the load-recording arm and of the drum causes the pen or pencil attached to the load-recording arm to trace a load-deflection curve similar to that shown in Fig. 3.

Fig. 2 gives a further idea of the construction of the deflectometer. The deflectometer is fastened to the testing machine by clamping the base plate to the head of the testing machine so that the rod of the extensometer is midway between the supports for the transverse bar. A spring under Collar B forces the end of the rod against the transverse bar and keeps it in contact with the bar throughout the test. As the transverse bar breaks, the rod flies downward, and it would push the rod so far as to break the dial gage unless Collar A limited the travel of the rod to ¾ in. The housing around the spring stops the downward flight of the transverse bar, and thus also assists in limiting the travel of the rod because the tip of the rod is flush with the top of the housing when Collar A is ⅛ in. above the shoulder in the housing.

Composition of Wedges and Shoes

The shoes through which the wedges slide are made of annealed carbon tool steel having a hardness similar to that of the wedges. In making the shoes, it is essential that the grooves be smooth so that the wedges will slide freely. A detail of the shoes is shown in the lower left-hand corner of Fig. 2.

The wedges are made of annealed flat tool steel stock. The wedge which acts primarily as a shock absorber is cut from 1/16-in. stock; the wedge attached to the recording drum from stock 1/32-in. thick. If desired, a few holes can be put in the wedges to lighten them. The wedges should be straight so they will not bind in the shoes. A guide to hold the wedges in position is made from brass angle, and is attached as shown in Fig. 2.

A dial gage is attached to the deflectometer as shown in Fig. 2. This gage is used only to check the accuracy of the deflectometer at regular intervals, and is not a permanent part of the deflectometer.

An autographic load-deflection curve obtained on a 2-in. diameter transverse bar is shown in Fig. 3. Dial gage readings taken during this test are plotted. The peak in the autographic-load deflection curve indicates the breaking load and deflection. In determining resilience the area under that portion of the curve between the origin and the peak is measured with a planimeter. Autographic load-deflection curves from three standard sizes of transverse bars are shown in Fig. 4. The curves for the 0.875-in.

Table of Comparison of Values Obtained by Dial Page with those Obtained from Autographic Curve

Breaking Load Lb.	Breaking deflection—In Ames[1] Dial	Breaking deflection—In Auto-[2] graph	Percentage of error in[3] deflection	Resilience Ft.-Lbs. Ames Dial	Resilience Ft.-Lbs. Auto-graph	Percentage of error in[3] resilience
			0.875-In. Bars			
1550	0.143	0.143	0	10.6	10.6	0
1540	0.134	0.133	—0.8	9.5	9.4	—1.0
1880	0.152	0.151	—0.7	13.1	12.9	—1.5
			1.2-In. Bars			
2600	0.235	0.236	+0.4	29.3	28.8	—1.7
2820	0.234	0.232	—0.9	30.4	30.2	—0.6
2790	0.253	0.249	—1.5	33.9	33.4	—1.5
			2-In. Bars			
8700	0.317	0.320	+1.0	141.7	141.1	—0.4
8470	0.299	0.303	+1.3	128.1	129.2	+0.9
8650	0.287	0.293	+2.1	123.4	125.1	+1.4

Notes

(1) Readings obtained with the dial gage.

(2) Values estimated from the autographic load-deflection curves.

(3) Per cent of error (relative =

$$\frac{\text{Dial gage value — Autographic curve value}}{\text{Dial gage value}} \text{ X } 100$$

and the 1.2-in. bars were obtained with the full scale of the testing machine at 7200 lbs.; those for the 2-in. bar, with a full scale range of 18,000 lbs.

Accuracy of the Instrument

The accuracy of the measurements is shown in the Table. The deflection values from the autographic load-deflection curves were estimated in the third decimal place much as one estimates the divisions on a slide rule. Since it is customary to report deflection values only to the closest one-hundredth inch, the values obtained with the deflectometer appear to be amply accurate.

The wedges become slightly roughened from the impact of the shoes when the specimen breaks. This slight roughening appears to have little effect on the accuracy of the values obtained. To prove this point, the calibration curve given in Fig. 5 was determined on wedges which had been used in breaking about 400 transverse bars of various sizes.

While the deflectometer just described is designed for one specific type of testing machine, it is adaptable to other types of testing machines by modifying the design somewhat. The deflectometer gives a permanent record and allows one man to make the transverse test.

The authors thank the Gray Iron Research Institute for permission to publish this description and express their appreciation of the assistance given them by the staff of Battelle Memorial Institute.

Reference

(1) Kenyon, Reid L. and Burns, Robert S. "Autographic Stress-Strain Curves of Deep-Drawing Sheet." *Trans. Amer. Soc. Steel Treating,* Vol. 21, pages 577-601.

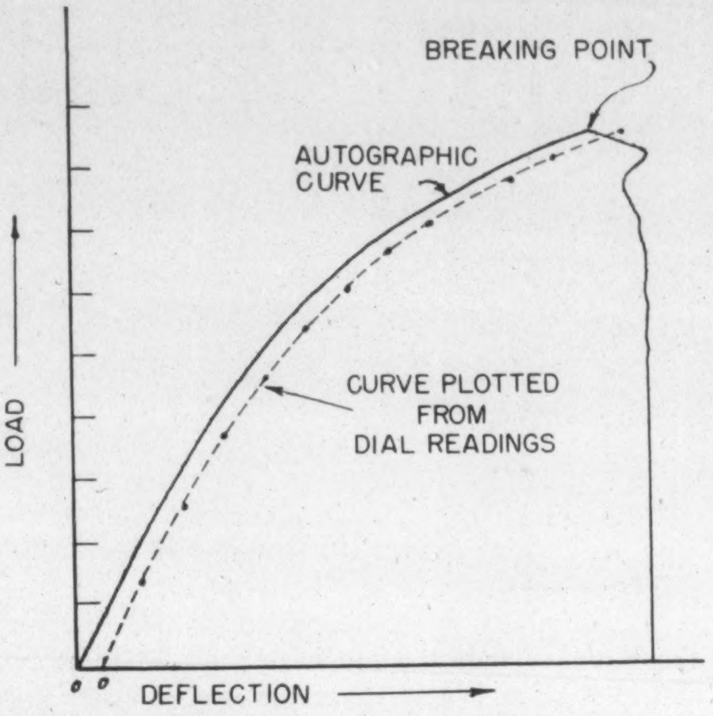


Fig. 3. Load-deflection curve for 2-in. transverse bar.

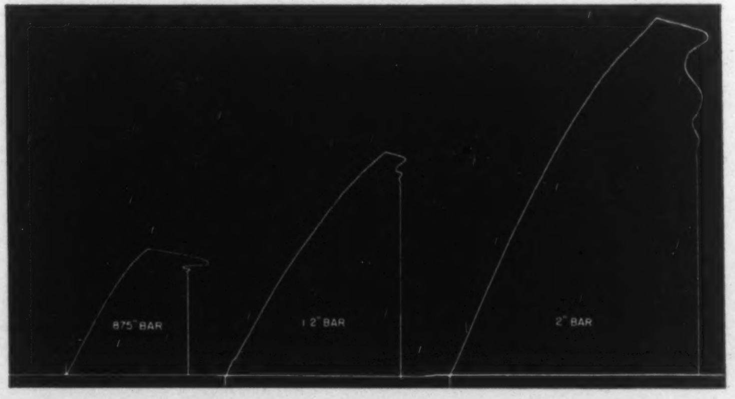


Fig. 4. Load-deflection curves from three standard sizes of transverse bars.

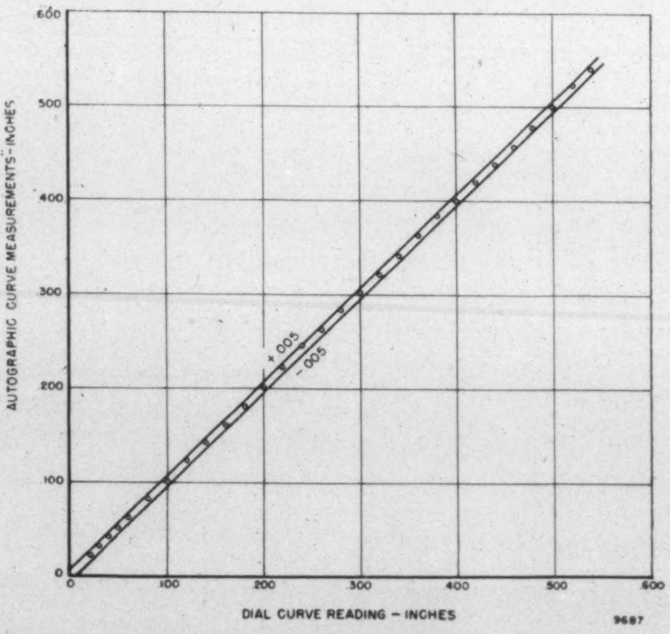


Fig. 5. Comparison of autographic and dial gage measurements.

Our Electric and Alloy Steel in 1940

by EDWIN F. CONE

SOME RATHER STRIKING RECORDS and trends have been a feature of the American electric and alloy steel industry for 1940. We have been watching the statistics and studying the trends in these two closely associated branches of the steel industry since their early inception. In spite of the fact that there may be some repetition in the following analysis, we are impressed with some of its features and an attempt is made in this article to briefly call attention to them and to present a fairly complete picture in one article or review.

The basis of this analysis is the annual statistics of the American Iron and Steel Institute—as in the past two years. While these data are not complete as to the total alloy steel produced, because they do not include the output of all the steel foundries (only the steel for castings made by ingot producers) nor do they include some steels which many would classify as alloy steels, they are representative of the bulk of the electric and alloy steel made. Hence they can be used as the basis for an analysis as to accomplishments and trends.

There are several outstanding features of the record for 1940—new totals in electric steel and in alloy steels made in electric furnaces, a large increase in the total alloy steel and stainless steel production as well as other interesting trends.

Total Electric Steel

A substantial increase was registered in 1940 in the total amount of steel made in electric furnaces. The total was a new high at 1,700,006 net tons or 6 per cent greater than the previous record in 1929. The striking feature of last year's total is that it rose to 2.54 per cent of the total steel produced—the first time a figure higher than 2 per cent has been reached. Table I presents these and other facts based on the Institute's statistics.

Electric Alloy Steel

A new high in the quantity of alloy steel made in electric furnaces was a feature of last year's record.

Table I—Electric Steel Output—Net Tons

Year	Total Electric Steel	Total Steel	Per Cent Electric
1920	566,370	47,188,886	1.20
1929	1,065,603	63,205,490	1.68
1933	471,747	26,020,229	1.81
1934	404,651	29,181,924	1.38
1935	606,471	38,183,705	1.58
1936	865,150	53,499,999	1.62
1937	947,002	56,636,945	1.67
1938	565,627	31,751,990	1.78
1939	1,029,067	52,298,714	1.95
1940	1,700,006	66,982,686	2.54

From Table II it can be seen that for the first time the 1,000,000-ton mark was exceeded. The 1,286,716 tons of electric steel was over 71.5 per cent in excess of the best previous total of 749,384 tons in 1939—a very marked expansion. And the percentage of electric alloy steel of the total alloy steel produced expanded to over 25 per cent for the first time, or 25.8 per cent.

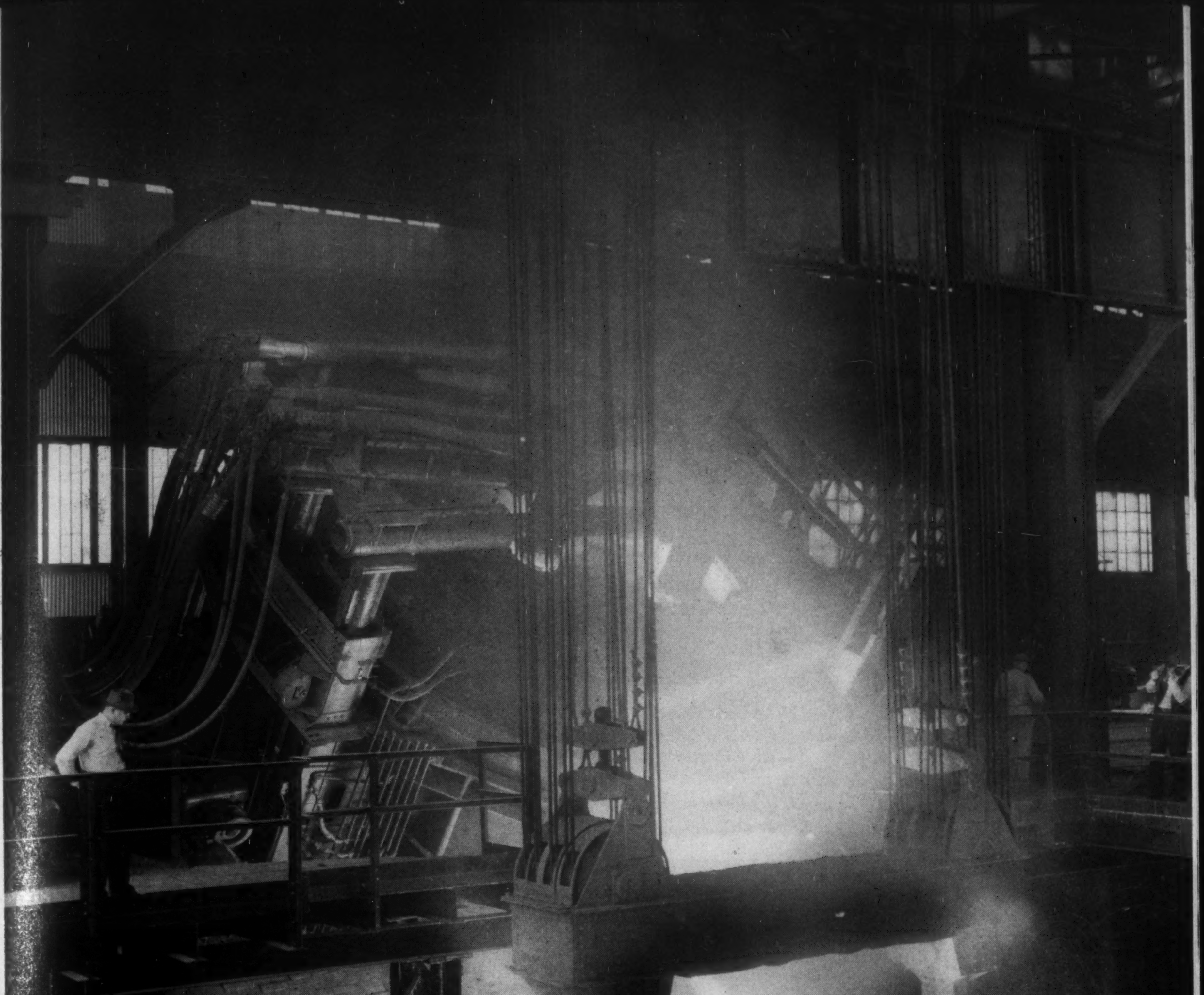
The Stainless Steels

Here again a new record was made in 1940. The 249,980 tons of stainless steels was an increase of about 39 per cent in excess of the previous record of 179,620 tons in 1939. Table III presents these data which have been collected by the Institute only since 1934 inclusive.

For the first time the 18 and 8 group represented a total which was about 50 per cent of the total stainless steels made; in 1939 this proportion was

Table II—Production of Alloy Steels Made in Electric Furnaces in the United States—Net Tons

Year	Electric Alloy Steel	Total Alloy Steel	Per Cent of Electric Alloy Steel of Total Alloy
1929	571,234	4,432,072	12.9
1935	462,071	2,374,017	19.4
1936	591,094	3,229,657	18.3
1937	672,616	3,396,541	19.8
1938	373,372	1,653,510	22.5
1939	749,384	3,211,955	23.0
1940	1,286,716	4,965,887	25.8



The new 65-ton round electric arc furnace recently installed and put in operation by Timken. It is said to be the second largest in the world. It poured 80 tons on its first heat, April 16, 1941. (Courtesy: Timken Roller Bearing Co.)

In the early days of the electric steel industry—one of five 6-ton furnaces first installed by Timken in 1916 and hand-charged. These were discarded in 1927. (Courtesy: Timken Roller Bearing Co.)

General view of the pouring floor of Timken's electric steel plant of 7 furnaces. At the extreme right is a 10-ton furnace now being replaced with a 20-ton unit. The second furnace is one of 35 tons. The larger furnaces, one of 85 tons and oval in shape, are at the far end.

about 45 per cent. This demonstrates the expansion in the demand for this type.

One should not lose sight of the fact that the increase in the demand for the 16 to 18 per cent Cr type of over 90.7 per cent last year over 1939 was greater than the corresponding expansion of only about 54 per cent for the 18 and 8.

While a new total for the stainless steels was a feature last year, Table IV shows that there was no gain in the percentage of the stainless steels of the total alloy steel made—only 5.04 per cent as compared with 5.60 per cent in 1939 and a high of 5.81 per cent in 1938. The average for the last 3 yrs. is 5.48 per cent, a creditable increase over the percentages for the previous 4 yrs.

Total Alloy Steel

In Table V there is assembled, based on the statistics of the Institute, the total alloy steel output for a period of years and its relation to the country's total steel production. To, and including, 1933, the data include both ingot and castings totals, but from 1934 to date (in italics) the table gives only steel ingots plus such castings as are made by ingot-producing companies.

In 1940 a new record was made in total alloy steel —4,965,887 tons. This total is impressive in that it is a gain of about 54.6 per cent over the 1939 total and exceeds by about 12 per cent the best previous record in 1929.

Also an interesting feature is that last year, of the total steel made, the alloy steel is 7.42 per cent, also a new high. In tons of steel to 1 ton of alloy steel (Table V) the record for 1940 at 13.5 tons is a sharp decline from recent years, due largely to the intense demand for the carbon and general run of steels which aggregated close to 70,000,000 tons.

Open-Hearth Alloy Steel

One should not lose sight of the fact that the open-hearth furnace is a large factor in the production of alloy steels, particularly automobile bar and other grades. But with the expansion of the electric furnace in this field, the proportion of the open-hearth product of the total is diminishing. For example, in 1940, alloy steels made in open-hearth furnaces totaled 3,674,926 net tons or 74.09 per cent of the total alloy steel. In 1939 this percentage was 76.60 per cent and in 1929 it was 84.65 per cent.

In General

In these unsettled times it is difficult to visualize the future. It is not improbable that new records in electric steel will be made in 1941—expansion in this field is very heavy. Demand for alloy steels for Defense and Aid-to-the-Democracies cannot help but increase. Whether the proportions cited above will hold or increase depends on many factors—a possible total steel output of 90,000,000 tons, the supply of alloying elements, the effect of priorities, and so on. The picture as a whole is an interesting one, especially when it is remembered that the electric and alloy steel industries were in their formative stages only 28 yrs. ago.

Summary

A recapitulation of the foregoing emphasizes these facts:

Total electric steel production for 1940 at 2.54 per cent of the total steel made was a new record—an impressive expansion.

At 25.8 per cent of the total alloy steel made in electric furnaces last year, the electric steel output established a new high—also impressive.

In the stainless steels a new high total was attained with 18 and 8 again in the forefront. Expansion in demand for the 16 to 18 per cent Cr type over 1939 was over 90 per cent, exceeding that for 18 and 8.

There was a decline last year in the percentage of stainless steels of the total alloy steel.

In total alloy steel produced a new record was established. The 1940 total was 12 per cent in excess of the previous record in 1929. The percentage of the total alloy steel of the entire steel production was 7.42 per cent, also a new high.

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"Trends in Stainless Steel Production," December, 1935, Vol. 6, page 347.

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"Trends in Alloy and Electric Steel Output," August, 1939, Vol. 10, page 255.

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Table III—Production of Stainless Steel Ingots—Net Tons

Year	"18 and 8"	12 to 14% Cr	16 to 18% Cr	All Others	Totals
1934	22,150	9,970	9,046	14,739	55,905
1935	27,676	14,820	14,377	16,707	73,580
1936	43,800	26,430	23,842	7,810	101,882
1937	66,212	33,938	27,550	28,918	156,618
1938	43,129	13,429	16,454	22,942	95,954
1939	81,144	22,453	34,230	41,793	179,620
1940	124,817	37,535	65,060	22,568	249,980

Table IV—Proportion of Stainless Steel of Total Alloy Steel—Net Tons

Year	Total Stainless	Total Alloy Steel	Per Cent Stainless
1934	55,905	1,805,748	3.10
1935	73,580	2,374,017	3.09
1936	101,882	3,229,657	3.16
1937	156,618	3,396,541	4.61
1938	95,954	1,653,510	5.81
1939	179,620	3,211,955	5.60
1940	249,980	4,965,887	5.04

Table V—Production of Alloy Steel Ingots and Castings in the United States—Net Tons

Year	Total Alloy Steel	Total Steel	Per Cent Alloy Steel	Tons of Total Steel to 1 Ton of Alloy Steel
1910	635,957	29,226,309	2.17	45.9
1915	1,143,685	36,009,160	3.17	31.4
1920	1,859,527	47,188,886	3.94	25.3
1925	2,724,930	50,840,747	5.36	18.6
1929	4,432,072	63,205,490	7.01	14.2
1930	2,736,508	45,583,421	6.00	16.7
1931	1,630,623	29,058,961	5.62	17.8
1932	894,436	15,322,901	5.83	17.1
1933	1,732,845	26,020,229	6.65	15.0
1934	*1,805,748*	*29,181,924*	*6.18*	*16.1*
1935	*2,374,017*	*38,183,705*	*6.21*	*16.0*
1936	*3,229,657*	*53,499,999*	*6.04*	*16.5*
1937	*3,396,541*	*56,636,945*	*6.00*	*16.6*
1938	*1,653,510*	*31,751,990*	*5.21*	*19.0*
1939	*3,211,955*	*52,798,714*	*6.08*	*16.4*
1940	*4,965,887*	*66,982,686*	*7.41*	*13.5*

Electrolytic Manganese

ALLOYED WITH COPPER AND NICKEL-I

by B. L. AVERBACH

Department of Metallurgy, Rensselaer Polytechnic Institute, Troy, N. Y.

In radio work, and sometimes in other connections, it is desirable to pack as much electrical resistance into as small a space as possible. While this report cannot give assurance that there are no "bugs" to be worked out, it does lay the foundations of an understanding of a group of extraordinarily high resistance alloys.

This article was abstracted from the senior thesis presented to the department of metallurgy at Rensselaer in June, 1940. The thesis later received the Ricketts Prize at the Institute for the best undergraduate thesis of the year. Other honors include a prize in a contest sponsored by the Electro Manganese Co. and one in a contest sponsored by the New York Section of the A. I. M. E.—The Editors.

EARLIER STUDIES on the manganese-copper system by Zhemchuzhnui and Petrashevich,[1] Hunter and Sebast,[2] Broniewski and Jaslan,[3] Korenev,[4] and Valentiner and Becker,[5] as well as studies on the Cu-Ni-Mn system by Pilling,[6] had indicated in the manganese-rich regions of these systems the presence of alloys with high electrical resistance. However, such alloys, made with silico-thermic or alumino-thermic manganese, were very brittle. In 1939, R. S. Dean and his associates,[7] investigating electrolytic manganese, reported workable Mn-Cu and Mn-Ni alloys with resistivities approaching 200 microhm-centimeters—among the highest ever recorded for ductile alloys.

The present investigation was undertaken to determine the effect of electrolytic manganese on the properties of the ternary Cu-Ni-Mn alloys. If these alloys are to be useful in electrical instrument construction, they should have, according to Pilling,[6] the following properties:

1. High resistivity.
2. Low temperature coefficient of resistance.
3. Low thermoelectric force vs. copper.
4. A useful degree of conductivity.
5. Permanence of electrical properties.
6. Insensitiveness to heat treatment.
7. Corrosion resistance.
8. Ability to solder and weld easily.

Each alloy in this investigation was considered from the point of view of the first six of these criteria.

Cold Malleability

This investigation showed that in general, the entire Cu-Ni-Mn system was ductile with the exception of alloys containing more than 97 per cent Mn and with the exception of certain alloys in the Mn-Ni series. (See Table 1)

Binary Mn-Ni alloys containing 50 to 75 per cent Mn were brittle, but an alloy of 80 per cent Mn and 20 per cent Ni (Alloy No. 18) was ductile, an alloy of 90 per cent Mn and 10 per cent Ni (Alloy No. 19) was again brittle, but an alloy of 95 per cent Mn and 5 per cent Ni (Alloy No. 20) was ductile. At the 50:50 Mn:Ni ratio, 2 per cent of Cu was sufficient to stabilize the ductile gamma phase after a drastic quench from 950 deg. C., but at the higher manganese ratios only 1 per cent of Cu was necessary to insure cold formability. As more copper was added, the less drastic was the quench required to retain the gamma modification.

At 97 per cent Mn, Alloy No. 62 (97% Mn, 1% Ni, 2% Cu) was ductile as cast, but became brittle upon slow cooling from elevated temperatures because of the precipitation of the beta phase. A drastic quench from 1100 deg. C. was necessary to restore the ductile gamma form. Alloy No. 61 (96%

TABLE 1

(R = Resistivity in Microhm—cm)

	Composition			As Cast		As Cast and Quenched		98% Reduction		Quench-ing Temper-ature deg. C.
No.	Mn	Ni	Cu	R	Work-ability	R	Work-ability	R—(cold worked)	R—(quenched)	
1	47.5	47.5	5.0	273	brittle	231	good	157	201	950
1a	47.5	47.5	5.0	204*	brittle	...	....	...	...	...
1b	47.5	47.5	5.0	312	brittle	...	....	...	...	...
2	42.5	42.5	15.0	184	good	180	good	153	181	950
2a	42.5	42.5	15.0	119*	brittle	...	....	...	...	...
3	37.5	37.5	25.0	155	good	146	good	137	144	850
4	50.0	50.0	...	256	brittle	325	brittle	...	...	950
4b	50.0	50.0	...	200	brittle	...	....	...	...	...
47	49.0	49.0	2.0	211	good	189	good	169	204	950
48	49.5	49.5	1.0	422	brittle	...	....	...	...	...
49	49.75	49.75	0.5	325	brittle	...	....	...	...	...
5	45.0	45.0	10.0	126	brittle	192	good	154	173	950
6	40.0	40.0	20.0	168	good	155	good	137	148	850
7	63.4	5.0	31.6	184	good	178	good	185	190	800
8	67.0	...	33.0	150	good	172	good	188	184	800
9	60.0	10.0	30.0	179	good	195	good	193	196	800
10	56.7	15.0	28.3	184	good	175	good	187	193	800
11	53.4	20.0	26.6	130	good	175	good	171	178	800
11a	53.4	20.0	26.6	176	good	176	good	161	170	800
12	46.7	30.0	23.3	169	good	174	good	160	169	850
13	67.0	33.0	...	201	poor	200	poor	...	...	950
14	60.0	40.0	...	187	brittle	173	poor	...	...	950
15	40.0	60.0	...	147	good	136	good	118	126	850
16	75.0	25.0	...	198	poor	234	poor	...	...	950
17	80.0	20.0	...	172	good	169	good	174	218	1000
18	85.0	15.0	...	162	good	157	good	159	196	950
19	90.0	10.0	...	152	fair	156	fair	...	...	950
20	95.0	5.0	...	128	good	117	good	116	131	950
21	100.0	...	...	162	brittle	...	....	...	...	...
21a	100.0	...	...	154	brittle	...	....	...	...	...
22	95.0	...	5.0	117	good	113	good	116	115	950
23	90.0	...	10.0	124	good	138	good	134	136	850
24	85.0	...	15.0	127	good	141	good	148	150	850
25	80.0	...	20.0	137	good	168	good	172	176	850
26	75.0	...	25.0	147	good	175	good	190	189	850
27	60.0	...	40.0	154	good	179	good	194	186	800
31	40.0	50.0	10.0	200	good	191	good	162	194	850
32	50.0	40.0	10.0	227	brittle	215	good	162	197	950
33	50.0	25.0	25.0	174	good	181	good	174	186	850
34	50.0	20.0	30.0	173	good	151	good	167	172	800
53	45.0	50.0	5.0	205	good	...	....	173	206	950
35	60.0	20.0	30.0	177	good	191	good	172	179	850
36	60.0	30.0	10.0	194	good	211	good	218	205	950
37	60.0	10.0	30.0	188	good	186	good	191	193	850
51	60.0	39.0	1.0	193	good	...	....	180	209	950
28	67.0	22.0	11.0	191	good	197	good	184	208	950
29	67.0	16.5	16.5	192	good	195	good	190	203	850
30	67.0	11.0	22.0	194	good	196	good	193	197	850
45	67.0	28.0	5.0	188	good	190	good	182	220	950
46	67.0	5.0	28.0	184	good	191	good	198	200	800
50	67.0	32.0	1.0	191	good	...	....	166	218	950
38	75.0	17.5	17.5	189	good	188	good	182	196	850
39	75.0	19.0	6.0	177	good	180	good	171	209	950
40	75.0	6.0	19.0	177	good	186	good	180	187	850
52	75.0	24.0	1.0	184	good	...	....	175	219	950
41	80.0	10.0	10.0	187	good	188	good	187	215	950
42	80.0	18.0	2.0	166	good	167	good	158	184	950
43	80.0	2.0	18.0	173	good	186	good	176	185	850
44	90.0	5.0	5.0	156	good	141	good	150	171	950
60	97.0	2.0	1.0	...	brittle	...	brittle	...	...	1100
61	97.0	1.0	2.0	...	good	...	good	75.5	112	1100
62	96.0	...	4.0	...	good	...	good	91	98.5	1100

* Cast into sand mold. Note: All alloys designated "As Cast" were drawn into 7 mm. pyrex tubing.

Mn, 4% Cu) behaved in a similar manner, but Alloy No. 60 (97% Mn, 2% Ni, 1% Cu) was extremely brittle and glass hard, and no treatment could make it workable.

Electrical Resistivity

Table 1 lists the resistivity as it was obtained for each alloy after each treatment, and Fig. 1, compiled from the results of Pilling, Hunter, and this investigation, summarizes the data on the resistivity of the Cu-Ni-Mn system.

It is evident that there is a large area between 40 and 80 per cent Mn in which high resistivity materials occur, and that the resistivity is dependent largely upon the manganese content. The substitution of nickel for copper has little effect upon the resistivity of these alloys.

At 67 per cent Mn (Fig. 2) cold work, solid solution and aging treatments had little effect on the

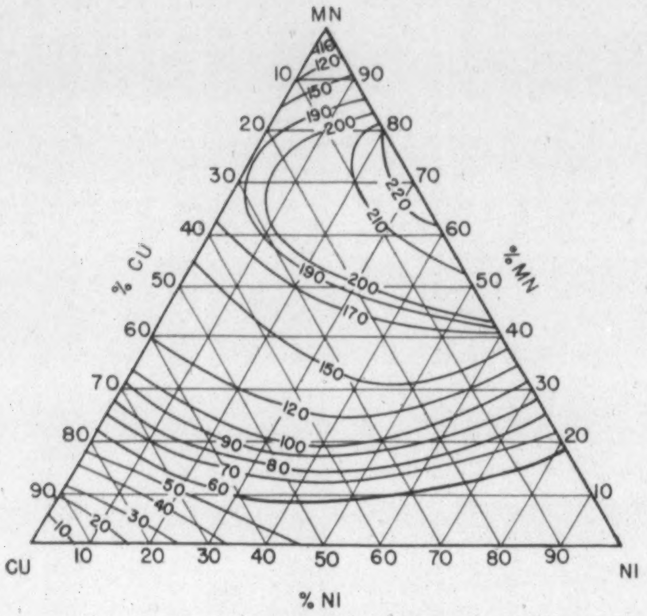

Fig. 1. Resistivity of Cu-Ni-Mn alloys in microhm-cm.

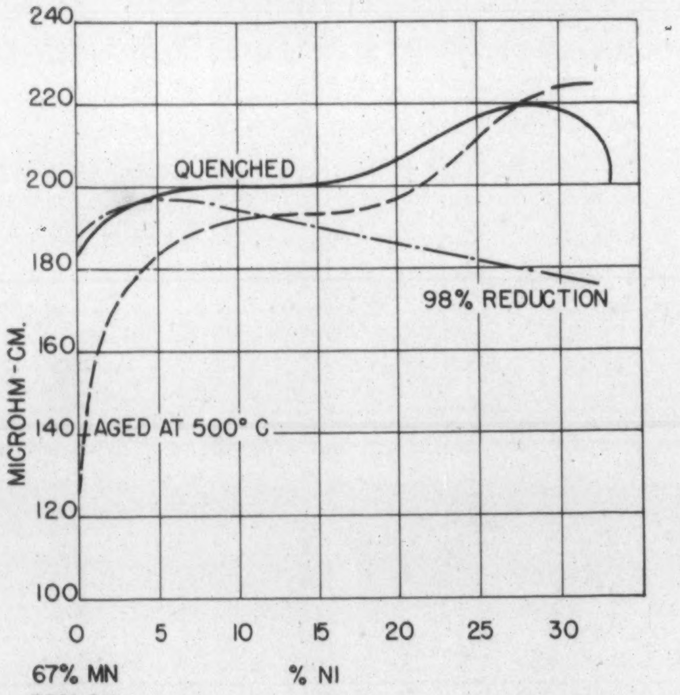

Fig. 2. Resistivity of Cu-Ni-Mn alloys at 67 per cent Mn.

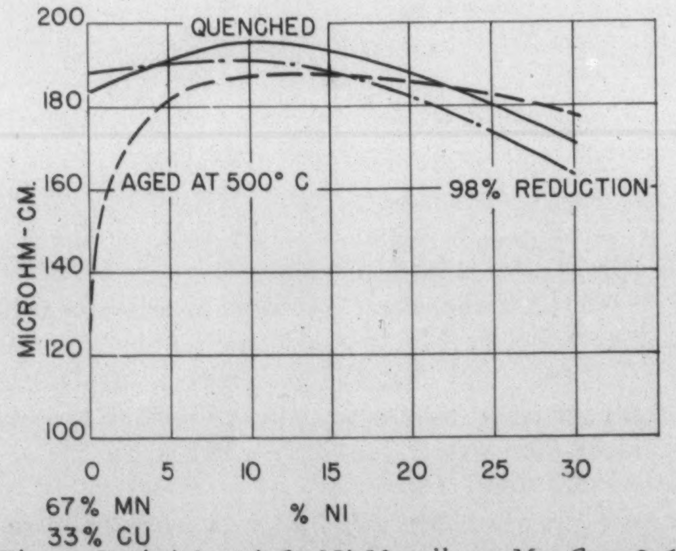

Fig. 3. Resistivity of Cu-Ni-Mn alloys. Mn:Cu=2:1.

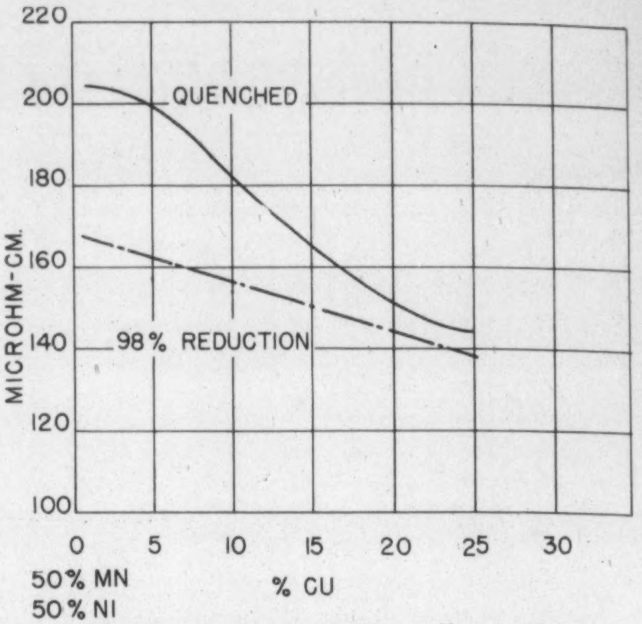

Fig. 4. Resistivity of Cu-Ni-Mn alloys. Mn:Ni = 50:50

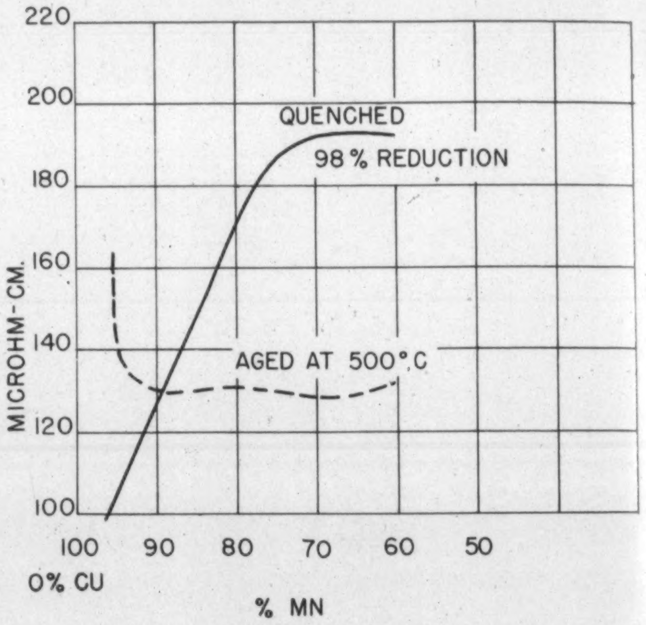

Fig. 5. Resistivity of Cu-Mn alloys.

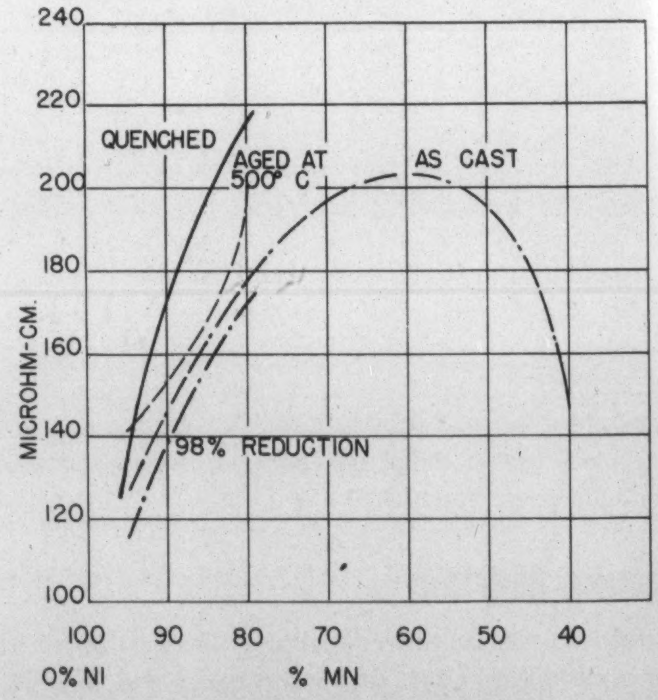

Fig. 6. Resistivity of Ni-Mn alloys.

resistivity or the ductility of the high manganese ternary alloys. The 2:1 ratio of Mn:Cu (Fig. 3) provided a series of alloys with the resistivity just under 200 microhm-centimeters; they showed a slightly decreasing resistivity as nickel was added, and little change after thermal treatment and cold work. When the Mn:Ni ratio was 50:50 (Fig. 4) the electrical properties exhibited large fluctuations upon treatment.

In the Mn-Cu system (Fig. 5) the resistance rose to a maximum between 60 and 70 per cent Mn but varied considerably with the rate of cooling. The Mn-Ni system (Fig. 6) showed slightly higher resistivities than the corresponding Mn-Cu alloys, and exhibited a significant divergence of resistivity with treatment.

Effect of Aging on Resistivity

From Table 3 it is evident that the alloys with a Mn:Ni ratio of 50:50 suffered a loss in ductility as well as a loss in resistivity on aging. This effect was noticeable for alloys containing as much as 25 per cent Cu.

Except for the binary alloys of Mn-Cu, aging had little effect upon the properties of the remaining Cu-Ni-Mn alloys. In Mn-Cu alloys above 90 per cent Mn the resistivity increased because of the high resistance of the beta phase which precipitated. After aging an alloy with 97 per cent Mn (Alloy No. 61—97% Mn, 1% Ni, 2% Cu) as well as an alloy with 96 per cent Mn (Alloy No. 62—96% Mn, 4% Cu) the resistivity rose from 100 microhm-centimeters to 200 microhm-centimeters, but the alloys became extremely brittle. When alloys with less than 90 per cent Mn were aged, however, the resistivities fell considerably (Fig. 5).

During any thermal treatment of these alloys, extreme caution was necessary to prevent excessive scaling and loss of manganese from the surface. At 300 deg. C. a protective atmosphere was necessary, and at 800 deg. C. only a few moments were necessary to form a low-Mn case. *(To be concluded)*

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Table 2

(R = Resistivity in Microhm—cm)

	Composition				As Cast		98% Reduction		
No.	Mn	Ni	Ag	Cu	R	Workability	R—(cold worked)	R—(quenched)	Quenching Temperature deg. C.
54	49.75	49.75	0.5	..	222	brittle	...	...	950
55	49.5	49.5	1.0	..	248	brittle	...	...	950
56	49.0	49.0	2.0	..	304	brittle	...	...	950
57	47.5	47.5	5.0	..	240	brittle	...	...	950
58	67.0	32.0	1.0	..	189	good	187	215	950
59	49.0	49.0	1.0	1	402	brittle	...	...	950

Table 3

No.	Mn	Ni	Cu	Resistivity (Microhm-cm.)	Aver. Temperature Coefficient of Resistance 22-90 deg. C.x10⁴	Thermoelectric force vs. Cu Microv. per 1 deg. C.
8	67	..	33	188	0.00	—1.0
28	67	22	11	208	—0.29	—0.20
29	67	16.5	16.5	203	+1.2	—0.50
45	67	28	5	220	—0.29	—0.12
46	67	5	28	200	—0.29	—1.20
50	67	32	1	218	+0.70	....
9	60	10	30	193	—0.28	—1.1
35	60	20	30	191	—1.0	—0.40
36	60	30	10	205	—1.0	0.00
51	60	39	1	209	0.00	....
38	75	17.5	17.5	189	—0.70	—0.30
52	75	24	1	219	+0.40	+0.40
41	80	10	10	215	—0.70	....
11	53.4	20	26.6	174	—1.1	—0.50
31	40	50	10	194	—1.0	+0.70
32	50	40	10	197	+1.6	+1.40
	Mn	Ni	Ag			
58	67	32	1	215	0.00	....

Forgings Versus Welded Assemblies

by J. A. PETRIE AND GEORGE W. PAPEN

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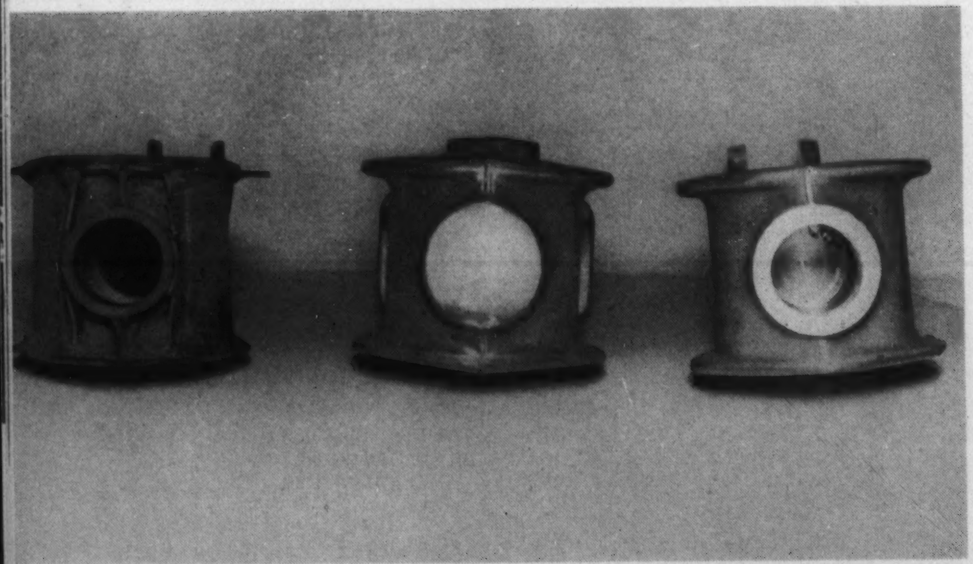
This article is of decided interest to designers of aircraft parts. These two production engineers in one of the country's large airplane plants tell the story of the factors that led up to the substitution of a forged aluminum fulcrum landing gear strut for one made of welded parts. The advantages gained are described as numerous.—The Editors.

The welded assembly for the fulcrum after heat treating and before machining.



End views of the welded assembly as well as the forging for the fulcrum—both before and after machining.

THE AIRCRAFT PARTS DESIGNER and the production engineer are faced with a serious problem of compromise between stress requirements, weight and cost to a much greater extent than any other design group. In the past forgings have never been considered in a very favorable light for several reasons, weight and cost perhaps being paramount. Weight, because inexperience in forging design led to forgings much heavier than welded assemblies; and cost, because of the fact that our limited production could not absorb the high die costs encountered. Of course we have always used some small forgings, usually weighing less than a pound but, for large structural members, weight and cost have dictated welded design.

In recent years we have learned something of forging design; this is coupled with the fact that forging companies are able to deliver better products, plus the fact that aircraft production has steadily risen to the point where in most instances we have little difficulty in absorbing a high die cost.

As an example of this change and also to illustrate some of the advantages gained through the use of forgings we have chosen a part, which shall hereafter be referred to as a fulcrum, a portion of the landing gear on the Lockheed 14 and 18 production models. It would be well at this point to keep in mind the fact that this particular part of our landing gear has to be held to an extremely high degree of accuracy, both from the standpoint of milling, boring, etc., and also because it has to be held to within plus or minus 10 minutes on the angular tolerances (in order to secure necessary alignment).

During the original design stages, we seriously considered making the part a forging; however, a weight check at that time proved that the forging, as designed, would be heavier than a welded unit and that the die cost, due to the design, was too high considering the fact that we were designing around a total production of only 50 ships.

The fulcrum as finally designed was a welded steel (X-4130) assembly consisting of some 12 parts, weighing 20.60 lbs. Not long after release, the model started selling and soon orders were piling up. The tool department, in order to produce this part sufficiently fast to keep up with production, designed and built some $10,000 worth of blanking dies, forming dies, checking fixtures, welding fixtures and machining fixtures.

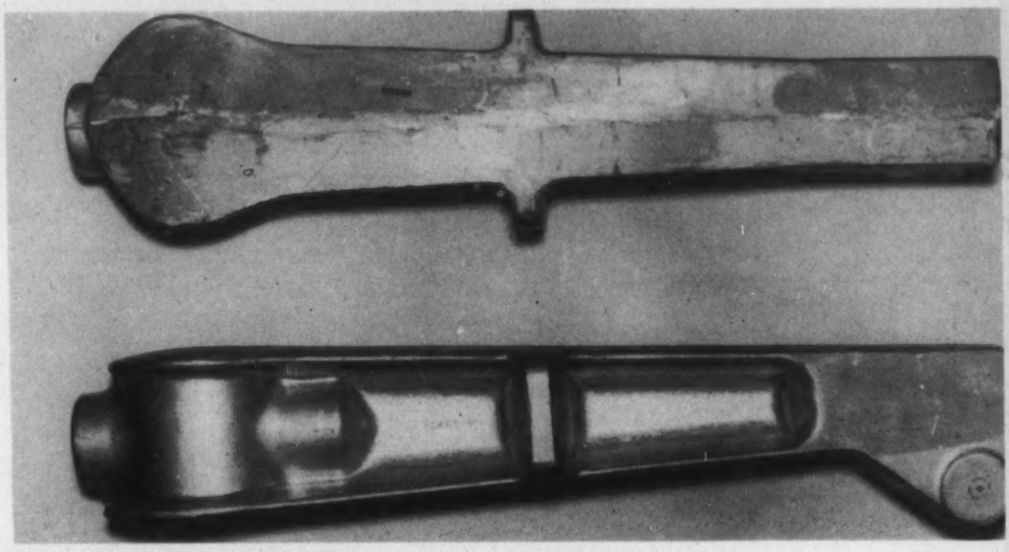
Here was a case where we had designed and tooled around a limited production run and then suddenly found ourselves confronted with fabulous figures and the all important element *time, time, time.* With a flight date to be met and severe penalty clauses in the contracts relative to that flight date, one is forced to lose sight of costs temporarily and start *producing.*

We did not deliberately go in for all of this tooling; it was one of those things that grew on us, so to speak. For instance, when we had trouble with warpage from gas welding, we switched over to arc welding; this necessitated that we design and build certain fixtures to alleviate the difficulty. Likewise when we got behind in production with reference to certain parts entering into the assembly, we designed and built more blanking dies, forming dies, etc., until the first thing we knew we had all of the tooling mentioned and the sad part of the story was we were still having trouble.

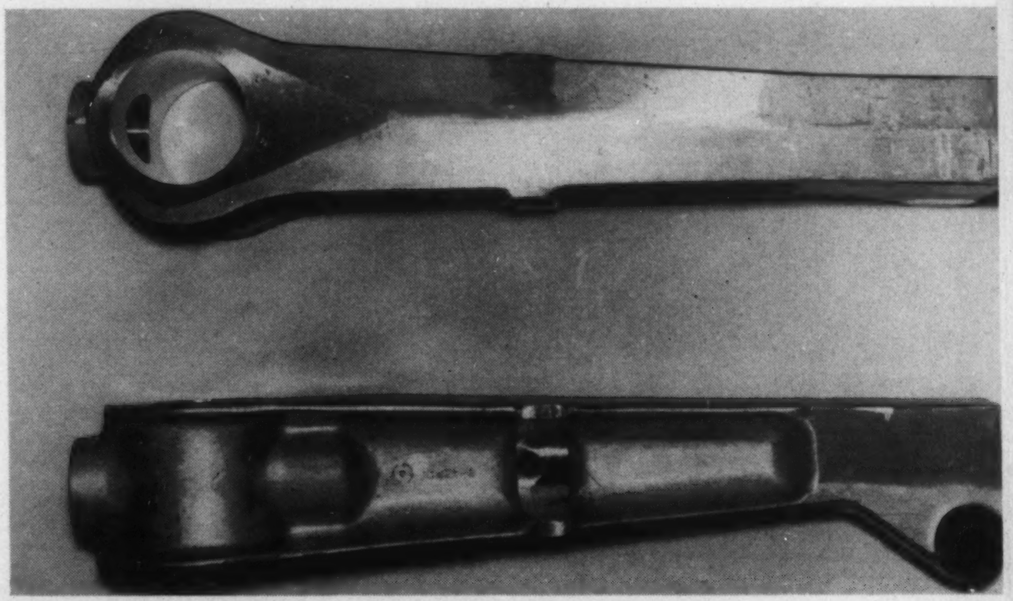
Trouble was a by-word; X-ray rejections on welded parts ran as high as 40 per cent. Rejections in the machine shop ran over 6 per cent. In fact at one time, when we were forced to farm the job out, due to pressure of meeting delivery dates, etc., we suffered as much as 80 per cent rejections. It was impossible to keep up with production.

Along about this time our engineering department had decided to modify the design of the ship somewhat, adding to its pay load. This in turn led to our redesigning some of the structure to carry a greater gross load; in this redesign it was necessary that we strengthen our landing gear to carry an additional 4,000 lbs. (The original design was based upon a 15,700-lb. gross weight, whereas the new design figure was 19,200 lbs.) This gave us the very opportunity we were looking for from a production engineering standpoint, so we immediately proposed that we design around a forging.

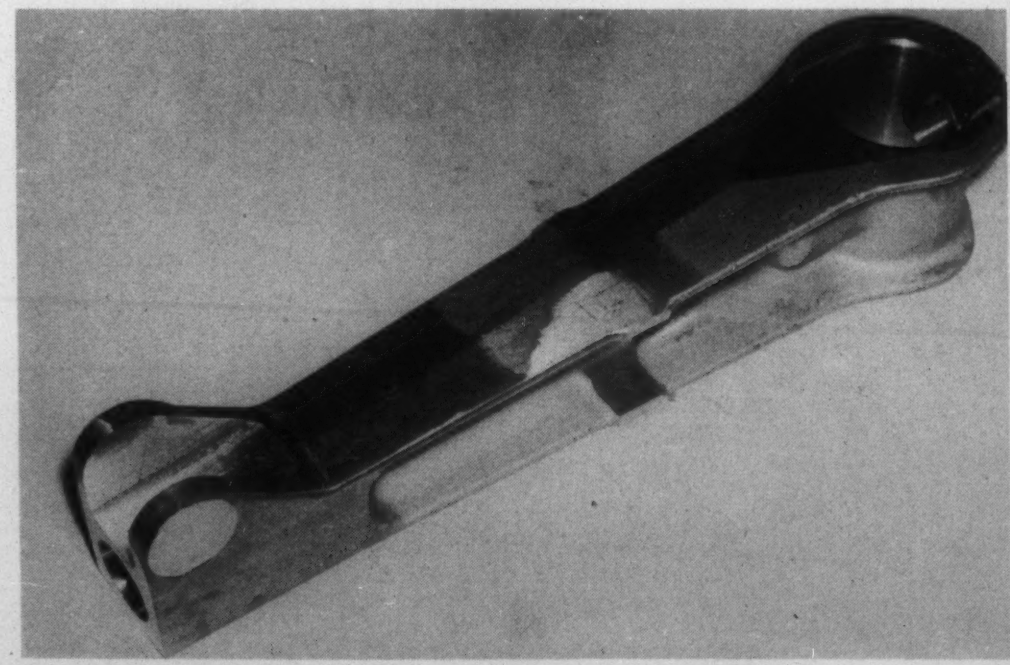
The fulcrum was finally redesigned as an aluminum alloy forging, (see illustration) and the advantages gained here are indeed quite numerous. In



The raw aluminum alloy forging for the fulcrum upon arrival at the plant and after being X-rayed.



The aluminum alloy fulcrum forging after machining. It is now ready for finish processing such as plating, painting, etc.



The completed aluminum alloy forging, finish machined.

the first place, we do not have any welding or heat-treating trouble. The forging makes a much neater looking job and it machines better and faster. We have less wear and tear on our cutters, (drills, milling cutters, etc.), whereas on the welded assembly we had to re-sharpen our tools at least once every 8-hr. shift. This, of course, was due to the fact that we were machining a welded chromium-molybdenum steel assembly heat-treated to 150,000 to 170,000 lbs. per sq. in.

Machining time was cut from 5 hrs. to 3 hrs. Percentage of rejections dropped to the almost unbelievable figure of one half of one percent, due to machining (and this due to an accident). X-ray rejections dropped to 1 percent. Finally, and this is important, the weight of the finished fulcrum went from 20.60 down to 17.38 lbs. in spite of its greater load carrying capacity.

Our die cost of $1800 was written off over some 500 ships (2 required per ship), and our forging costs (plus machining) run about $40. Compare this with our costs on the welded design (per unit) of some $60 with a tool cost (as outlined above) of some $10,000. The substitution of a forging netted us $40 per airplane and cured one of our worst headaches.

A comparison of the fulcrum landing gear strut as a welded steel assembly and as a forging follows.

THE TWO MATERIALS COMPARED

Welded Steel Assembly	Forging (Aluminum)
Completed part contains 12 pieces, arc welded together.	Completed part consists of one piece.
Fabrication time of the 12 pieces: $\frac{1}{2}$ hr.	No fabrication time.
Assembly time (welding): $2\frac{1}{2}$ hrs.	No assembly time.
Note: Gas welding was tried for a short time but considerable difficulty was encountered due to warpage, etc. We then switched over to arc welding. This eliminated a lot of our trouble; however, in view of the high heat-treat—150,000 to 170,000—it has always been necessary to return the parts to the metal fittings dept. for straightening in the hydraulic press. Time consumed here about 15 min.	No welding. No straightening operation.
Machining time of about 5 hours each. Tools have to be reground once in every eight hour shift, resulting in a very low tool life.	Machining time of $2\frac{1}{2}$ hrs. Tools have not been resharpened to date in spite of the fact that we have run some 400 parts.
Percentage of rejections after machining runs about 5 percent normally; however, at one time when it became necessary to farm the job out to an outside machine shop (due to pressure of other business) we suffered 80 percent rejections.	Percentage of rejections to date (400 parts), $\frac{1}{2}$ percent, and this due to an accident on the part of the machine operator.
Percentage of rejections due to flaws detected by X-ray runs between 5 and 8 percent.	Percentage of X-ray rejections have been about 1 percent.
Weight of finished part 20.60 lbs.	Weight of finished part 17.38 lbs.
Tooling required cost about $10,000.	Cost of tooling required, forging die, etc., $2,000.
Cost of the completed assembly (amortization of jigs, fixtures, etc.) $60.	Cost of the finished forging (amortization of forging die, etc.) $40.
Production run (one man) in an 8-hr. day—about $1\frac{1}{2}$ parts.	Production run (one man) in an 8-hr. day—about 3 parts.

Hydrogen in Steel and Cast Iron—III

AND DEFECTS IN APPLIED COATINGS

by C. A. Zapffe and C. E. Sims

Research Engineer and Supervising Metallurgist, respectively, Battelle Memorial Institute, Columbus, Ohio

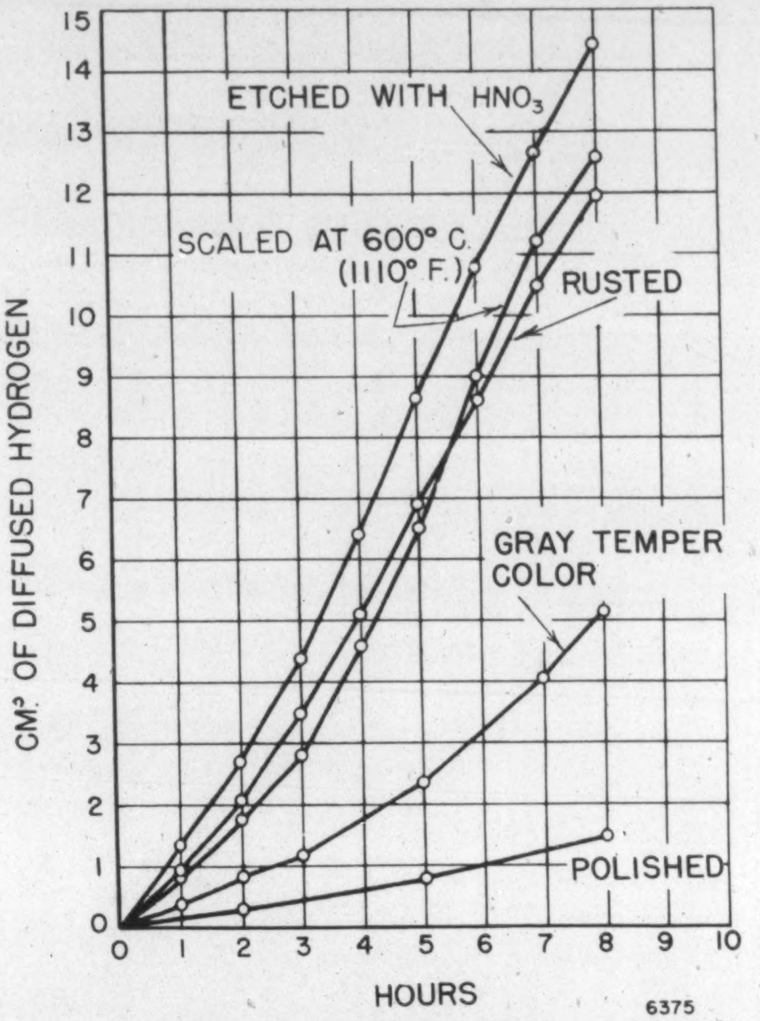


Fig. 12. Influence of surface oxidation on the absorption of hydrogen during pickling. (Baukloh and Zimmermann).

Hydrogen Absorption at Ordinary Temperatures

Acid Pickling

Effect of Surface and Thickness of Metal: Although a great deal has been written on hydrogen absorption during acid pickling, there are some important aspects that apparently have not been treated in English literature. For example, an oxidized surface may increase hydrogen absorption ten-fold[14] (see Fig. 12). Cold-working increases the chemical activity and probably the area of the surface, so that, during pickling, hydrogen evolution and absorption are greatest at cold-worked areas (See Fig. 13), and there is apparently an opening of internal rifts by the deformation which increases the occluding capacity of the steel. Conversely, however, cold-working also acts to remove hydrogen from steel once the external atomic hydrogen is removed. The effect appears catalytic in nature and depends in direction merely upon the direction of the diffusion gradient.

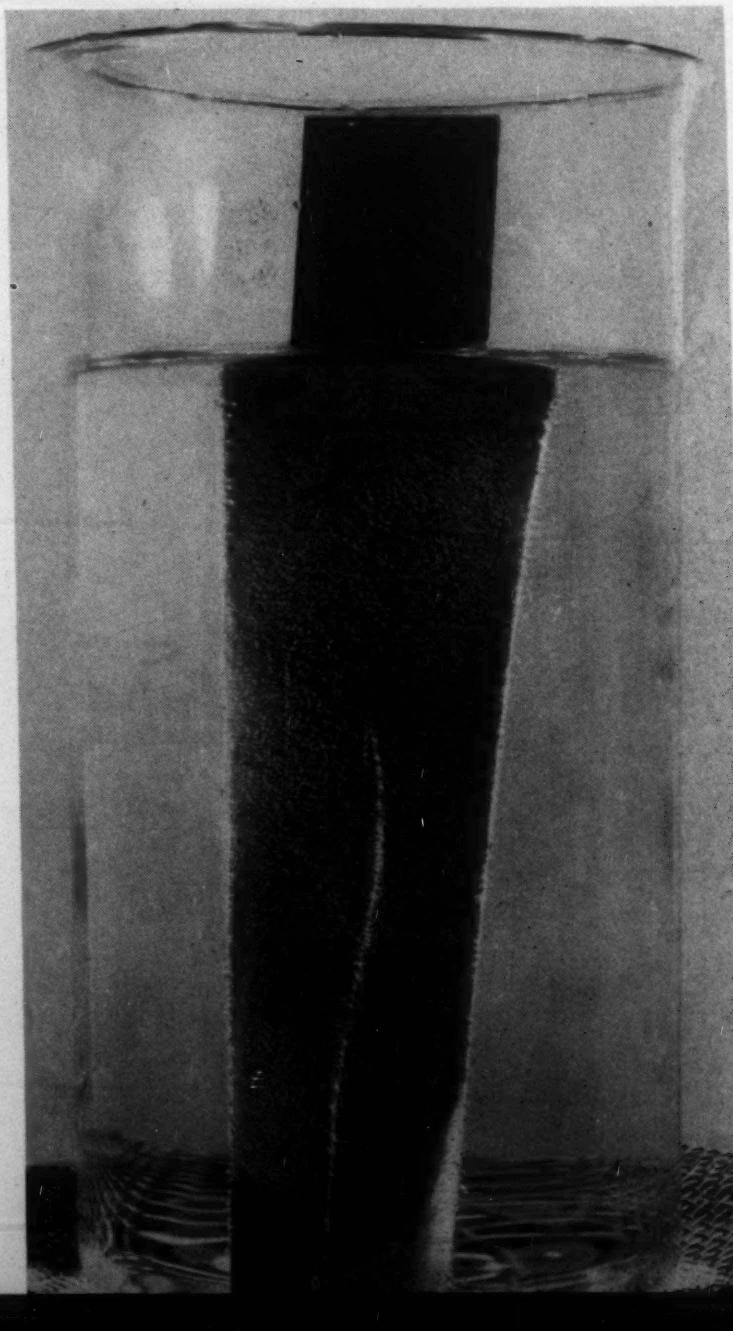


Fig. 13. Mild steel sheet in dilute acid showing preferential hydrogen liberation at cold-worked areas, such as sheared edges and scratches.

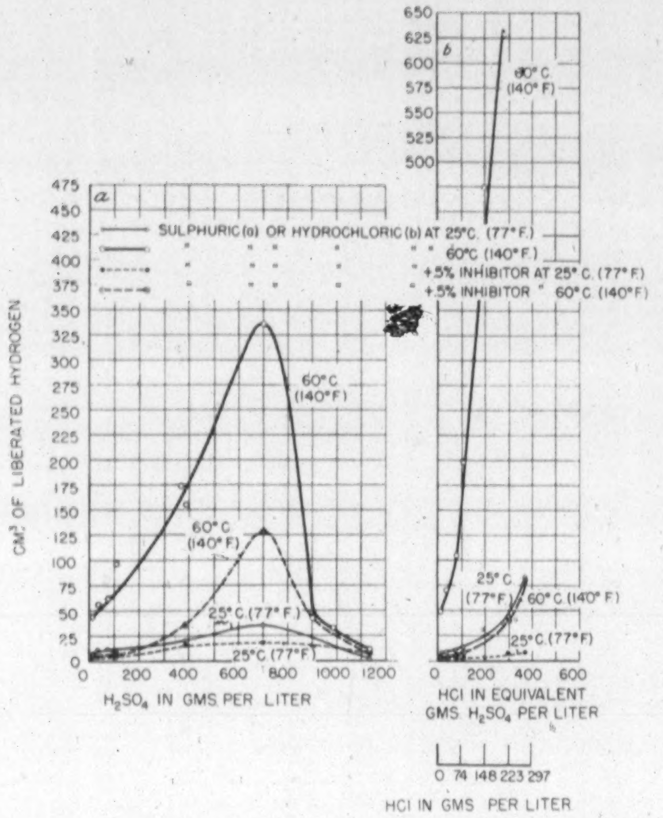


Fig. 14. Relation of hydrogen liberation to acid concentration (0.05-in. sheet. Surface—15.5 sq. in. Time—1 hr.) (Bardenheuer and Thanheiser.)

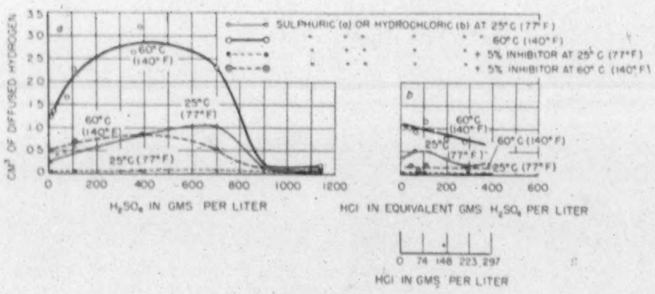


Fig. 15. Relation of hydrogen absorption to concentration of the acid. (0.05-in. sheet. Surface—15.5 sq. in. Time—1 hr.) (Bardenheuer and Thanheiser.)

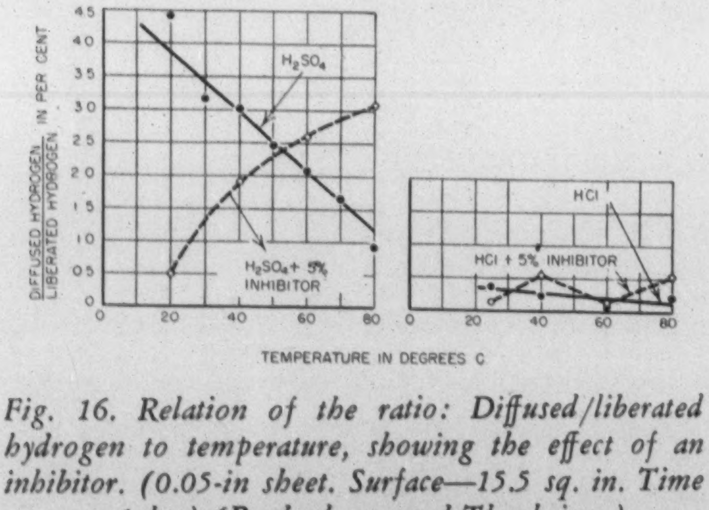
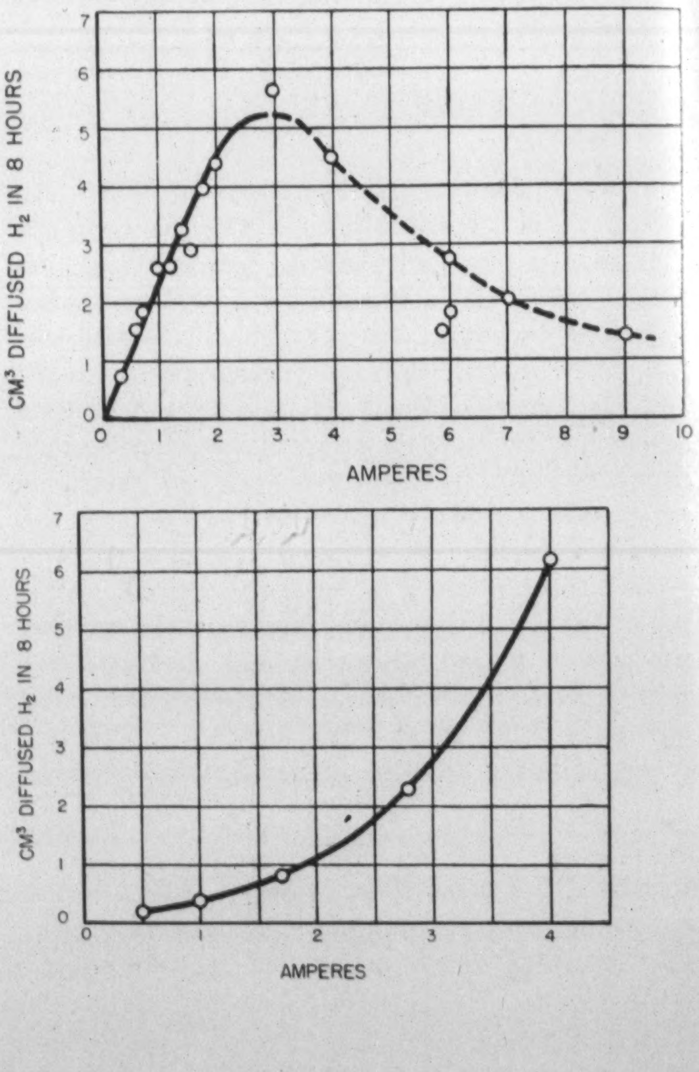


Fig. 16. Relation of the ratio: Diffused/liberated hydrogen to temperature, showing the effect of an inhibitor. (0.05-in sheet. Surface—15.5 sq. in. Time—1 hr.) (Bardenheuer and Thanheiser.)

Effect of Temperature and Concentration of the Acid: Increasing the temperature of a pickling solution from 20 to 80 deg. C. (68 to 176° F.) will cause about a 30-fold increase in hydrogen absorption. However, the ratio of absorbed to liberated hydrogen actually decreases about 5-fold over this temperature interval, so if cleaning a specimen were dependent only on a given total quantity of developed (liberated plus absorbed) hydrogen, less would be absorbed at the higher temperature, for a much shorter time would be required to clean the piece. Otherwise, it may be advisable to pickle at lower temperatures where diffusion is less rapid in spite of the fact that a greater percentage of the developed gas is absorbed.

The effect of acid concentration and temperature on liberated, or evolved, hydrogen for both sulphuric and hydrochloric acids is shown in Fig. 14, and the contrast of the curves is unexpected. Similar curves for absorbed hydrogen are shown in Fig. 15. It may be seen that hydrochloric acid provides less absorption and has a lower ratio of absorbed ("absorbed" and "diffused" may be used synonymously here, for the absorption was measured in terms of that which

Fig. 17. Relation of hydrogen absorption to current density (0.01-in. sheet. Surface—10 sq. in. Temperature—25 deg. C. (75° F.) (Above) 10 per cent H_2SO_4. (Below) 10 per cent HCl. (Baukloh and Zimmermann.)



diffused through a given thin sheet) to liberated hydrogen than does sulphuric acid; also, that, in contrast to sulphuric acid, which shows maximum values, absorption from hydrochloric acid pickling regularly decreases and the liberation increases with increasing acid concentration.

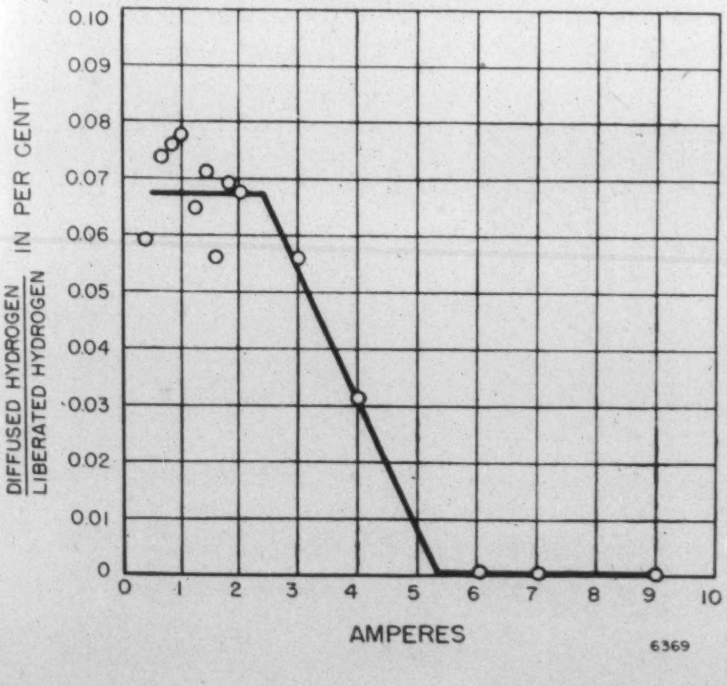
Inhibitors

The two previous figures also contain data showing the effect of an inhibitor. Inhibitors in general have favorable and unfavorable temperature ranges, and, if the ratio of absorbed to liberated hydrogen is studied, curves may be found as shown in Fig. 16. An inhibitor may thereby effect an apparent diminution of liberated hydrogen in pickling baths at elevated temperatures, but may at the same time be permitting a considerably increased absorption over that which would occur at lower temperatures.

Cathodic Electrolysis

Comparison with Acid Pickling: The absorption of hydrogen during cathodic electrolysis is generally similar to that during acid pickling. Both processes provide a great partial pressure of diffusible atomic hydrogen to the surface of the steel, and temperature and physical effects operate on absorption quite similarly in both cases. Exceptions are considered in another paper.[2] However, for a given hydrogen liberation, steel generally absorbs less hydrogen during cathodic electrolysis than during acid pickling, probably because conducting surface films often serve in cathodic electrolysis to de-ionize the hydrogen before it reaches the iron lattice. In pickling, the acid reaction involves replacing hydrogen atoms with iron atoms, and contact is optimum.

Fig. 18. Relation of the ratio: Diffused/liberated hydrogen to current density for a 10 per cent H_2SO_4 solution. (Same conditions as in Fig. 17.) (Baukloh and Zimmermann.)



Effect of Current Density

Fig. 17 shows contrasting effects of current density on hydrogen absorption from sulphuric and hydrochloric acid electrolytes,[14] and Fig. 18 shows an interesting effect of current density on the ratio of absorbed:liberated hydrogen for a sulphuric acid electrolyte.

"Promoters"

The effect exerted by some elements, particularly those in the Fifth and Sixth Groups of the Periodic Table, in increasing hydrogen absorption from a given bath is remarkable. Fig. 19 shows the effect illustratively, and it is seen that the presence of these

Fig. 19. Effect on the ratio of absorbed/liberated hydrogen of 10-milligram additions of impurities to 10 per cent H_2SO_4 solution. [Current density—10 amp. per sq. ft. Temperature—25 deg. C. (75° F.)] (Baukloh and Zimmermann.)

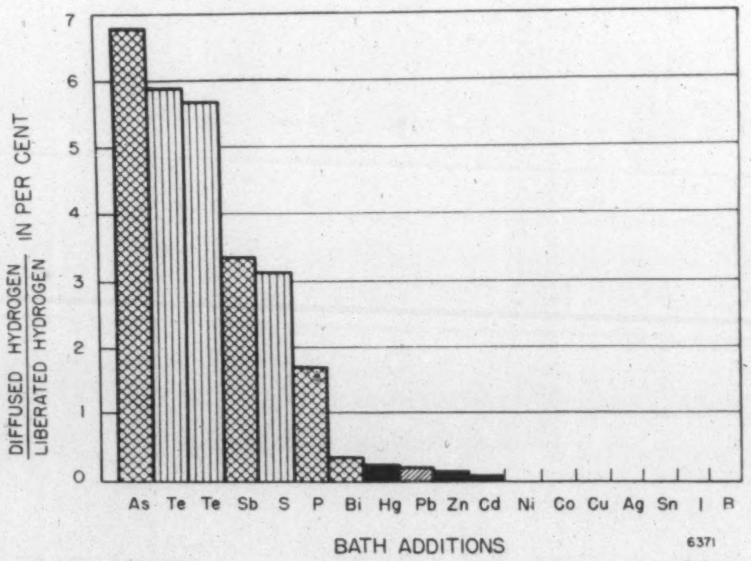
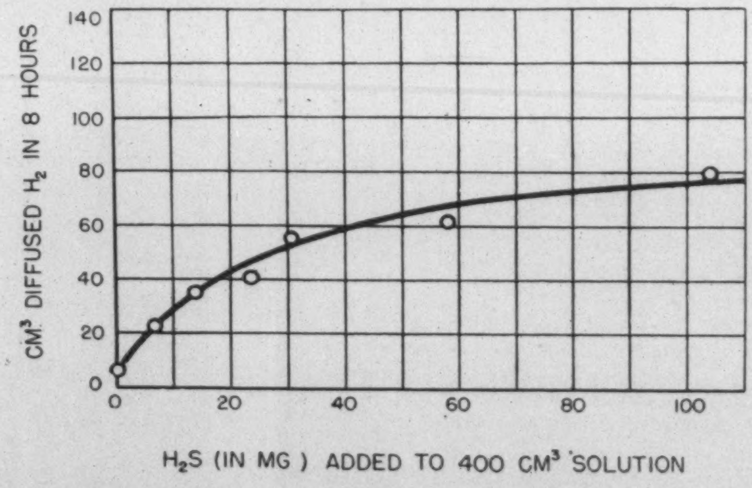


Fig. 20. Effect on hydrogen absorption of adding H_2S to 10 per cent H_2SO_4 electrolyte. (Previous conditions with current density—10 amp. per sq. ft.) (Baukloh and Zimmermann.)



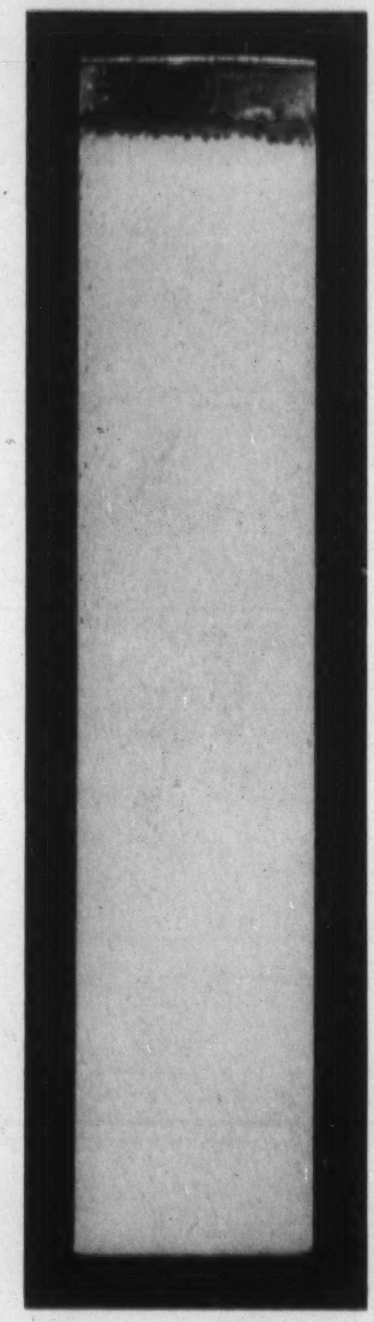


Fig. 21. Gas pits in nickel plate on steel caused by hydrogen effusing from the steel during electroplating. Top half of specimen cleaned cathodically and bottom half anodically.

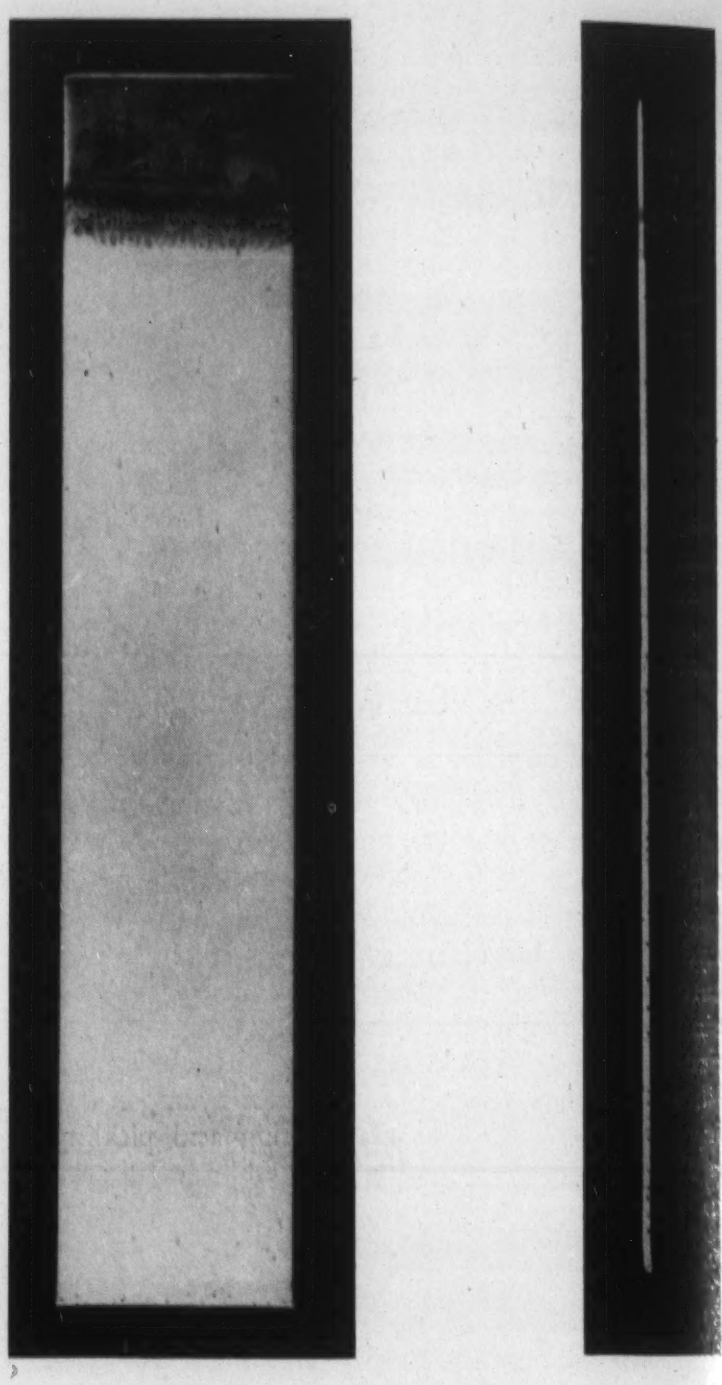


Fig. 22. Gas pits in coating on specimen cathodically cleaned in an alkaline bath. Left: Front. Right: Side—showing preferential location of pits.

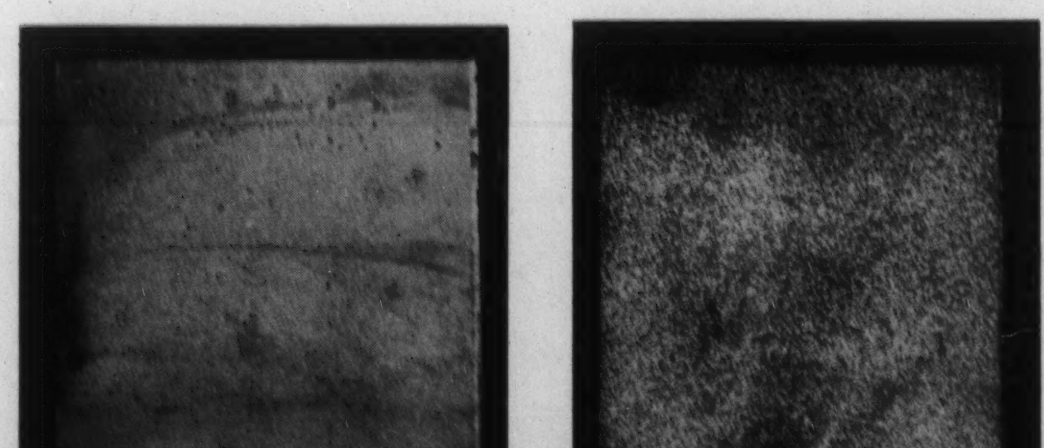


Fig. 23. Hydrogen blisters in cadmium coating on steel when heated to 210 deg. C. (410° F.). (Left) Specimen cleaned cathodically. (Right) Specimen cleaned anodically.

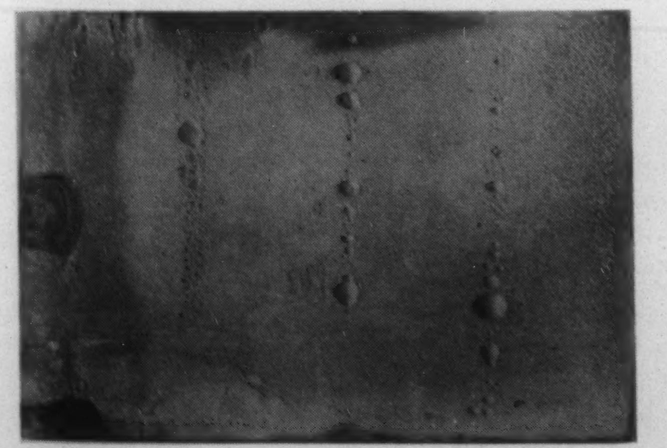
elements greatly increases the ratio of absorbed to liberated hydrogen. Small amounts of arsenic can increase the hydrogen absorption 100-fold. In fact, some evidence has been produced to show that iron will not absorb hydrogen in the absence of such impurities.[15] The important aspect is that these elements may be supplied inadvertently by the cathode itself, for several of the promoters, namely arsenic, sulphur and phosphorus, are common impurities in steel. Fig. 20 shows that hydrogen absorption can be increased 10-fold by adding H_2S to an electrolyte. Small amounts of HCN also may be very effective. The levelling of the curve in Fig. 20 is primarily due to depletion of the H_2S by oxidation at the anode to free sulphur, which proceeded to float on the bath as yellow flakes.

Addition of these elements to a hydrochloric acid electrolyte effects an equal or greater absorption than in sulphuric acid in the case of tellurium or selenium, and a lesser absorption for arsenic—probably because there is free chlorine in the bath. Mercury is three times as effective in hydrochloric as in sulphuric acid and H_2S and phosphorus show no effect whatsoever. The effect of such additions to acetic acid has also been studied.

The cause of the increased absorption that occurs in the presence of these impurities is unknown, and has been variously explained as a function of increased overvoltage or as a poisoning effect on the catalysis that otherwise favors the combination of the deposited hydrogen atoms to form escapable molecular hydrogen. Perhaps the low hydrogen overvoltage of iron is caused by the fact that iron catalyzes the reaction

$$2H \rightarrow H_2$$

Fig. 24. Anodically cleaned specimen of previous figure after machining coating as shown and subsequently loading cathodically with hydrogen. Hydrogen has entered the sheet where the steel is exposed and has diffused through the sheet to blister the coating on the opposite side. Right: Back. Below: Front.



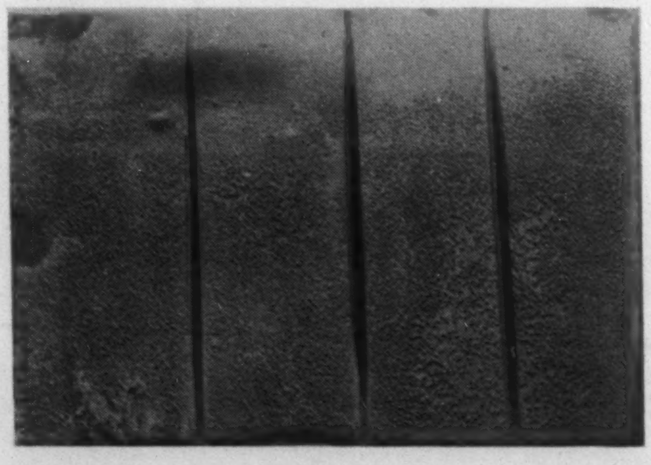
Rusting

Any reaction that increases the partial pressure of atomic hydrogen at the surface of iron and steel will cause increased absorption. Rusting appears to be a factor in this regard that has been underestimated. Admittedly, it is the least important of the processes discussed herein, but cast iron, if allowed to stand in air for some time after sandblasting, develops blistering when subsequently fired with vitreous enamel; and Moore[16] finds that iron, particularly when cold-worked, absorbs surprising quantities of hydrogen just by standing in air, and that the absorption increases with increasing humidity. Uncompleted tests in the present research corroborate these findings.

Hydrogen Effusion at Ordinary Temperatures

Defects in Electroplate

Gas Pits: Once the supply of atomic hydrogen on the surface of steel is reduced or removed, such as by cessation of pickling or cathodic electrolysis, the diffusion gradient at the surface reverses and the absorbed gas proceeds to effuse. An interesting effect of such effusion, first determined in the present research, is that during electroplating the effusion acts to prevent deposition of metal over the tiny source that effuses, with the result that "gas pits" are



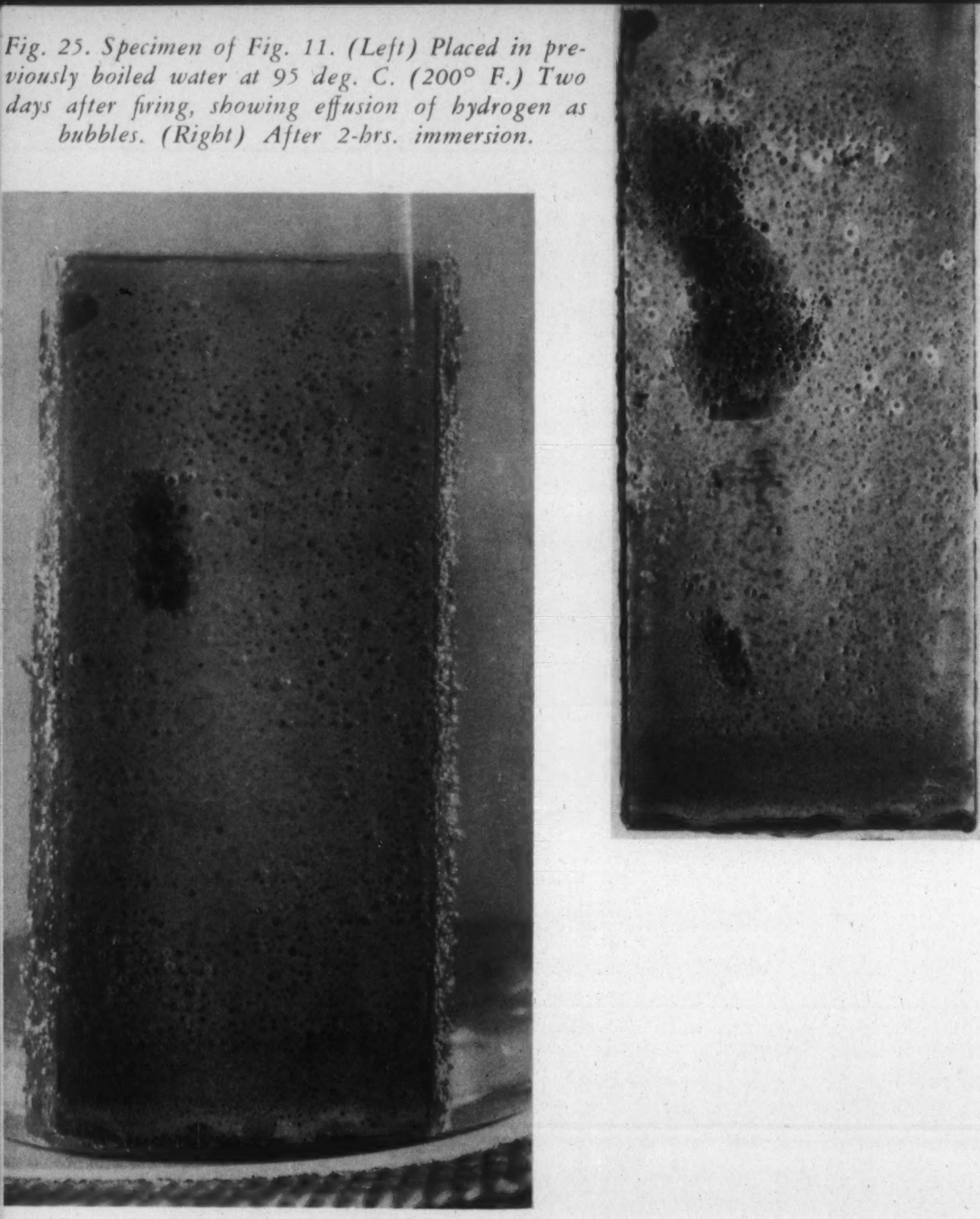
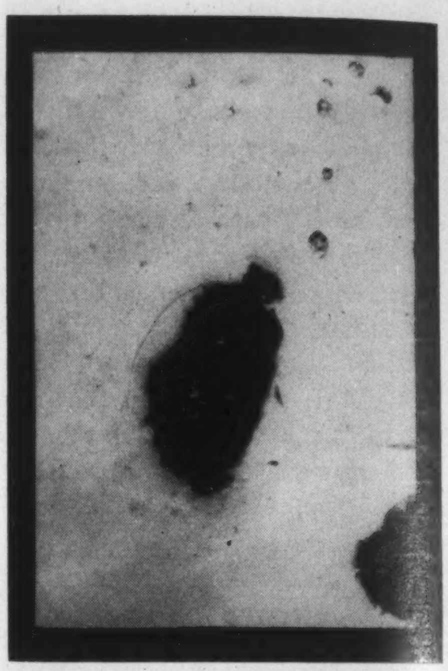


Fig. 25. Specimen of Fig. 11. (Left) Placed in previously boiled water at 95 deg. C. (200° F.) Two days after firing, showing effusion of hydrogen as bubbles. (Right) After 2-hrs. immersion.



Fishscale in cover coat directly overlying blisters in the ground coat.

formed (See Fig. 21). The half of the specimen in the Figure that shows no pits was cleaned anodically and therefore contained a minimum of hydrogen; the other half was cathodically cleaned and absorbed hydrogen. Cathodic electrolysis in an alkaline solution has the same effect as in acid in supplying hydrogen to steel (See Fig. 22). Note in Fig. 22 that, as discussed earlier in the case of enameling, the effusion is more severe along the edges of the steel than on the faces.

Blistering and Lifting: Effusion after the plate has been applied obviously may cause defects that depend in appearance upon the physical properties of the plate and the quantity of the effusion. Soft coatings, such as cadmium, may blister, especially when warmed (See Fig. 23), though the same may obtain when cold if the effusion is sufficient (See Fig. 24).

If the plated coating is less plastic, or if the effusion occurs over an area instead of from a point, lifting or poor adherence may result.

Defects in Vitreous Enamel

"Fishscaling": Many terms used in enameling bot cast iron and steel, such as "fishscales," "delaye fishscaling," "shiners," "crystallites," "jumpers," "pop offs," "chipping," "bursting," etc., may b telescoped for most cases into one generic term tha recognizes hydrogen effusion as a principal cause, a shown in the present investigations.

Fig. 25 (left) shows the heavy steel plate of the previous Fig. 11 placed in hot water. It may be seen that hydrogen is still effusing after firing, that many water bubbles overlie previously formed enamel bubbles, and that the effusion is more severe in the rolling directions, as discussed.

Fig. 25 (right) shows that the continued effusion has largely exploded away the heavy seam of enamel, which was purposely applied, and many enamel bubbles are exposed beneath. Fig. 26 shows a chipped cover coat exposing bubbles in the ground coat.

(To be concluded)

METALLURGICAL ENGINEERING news

Equipment
Finishes
Materials
Methods
Processes
Products

Alloys
Applications
Designs
People
Plants
Societies

Testing and Inspection

With this issue dedicated in some measure (no pun intended) to testing and to the annual meeting of the American Society for Testing Materials, it is appropriate to emphasize here some very recent developments in new apparatus for testing and inspection. Most of them reflect in some way current defense-production activity—the necessity for meeting "aircraft quality" standards, for "mass-production" inspection, etc.

Electric Thickness Gage for Non-Magnetic Metals

A new type of electric gage, developed for measuring the wall thicknesses of hollow aluminum airplane propellers, has been built in the general engineering laboratory of *General Electric Co.*, Schenectady, N. Y. The instrument is applicable to thickness measurements on any non-magnetic metal when only one side is accessible, even if the non-magnetic metal is backed up by iron or steel.

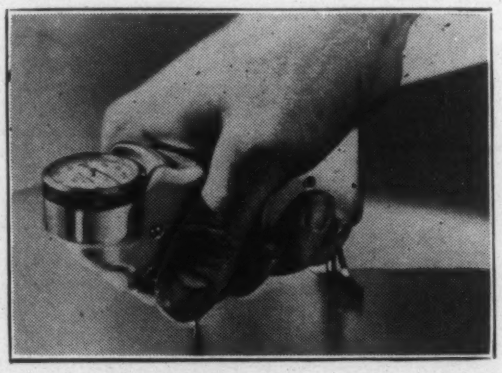
Thicknesses up to 1½ in., depending on the electrical resistivity of the metal, can be measured within 5%. The new instruments are already in use in a propeller factory and in copper and brass rolling mills.

The gage head, when placed against a non-magnetic metal, sets up eddy currents within the metal that change the head impedance and affect the circuit bridge balance. The eddy currents increase with the thickness of metal. The higher the resistivity of the metal, the greater is the thickness that can be measured.

Hardness Tester for Soft Materials

A new hardness tester, known as the "Impressor" and designed especially for use on aluminum alloys, other soft metals, plastics, hard rubber, etc., is now available from *Barber-Colman Co., Electrical Div.*, Rockford, Ill.

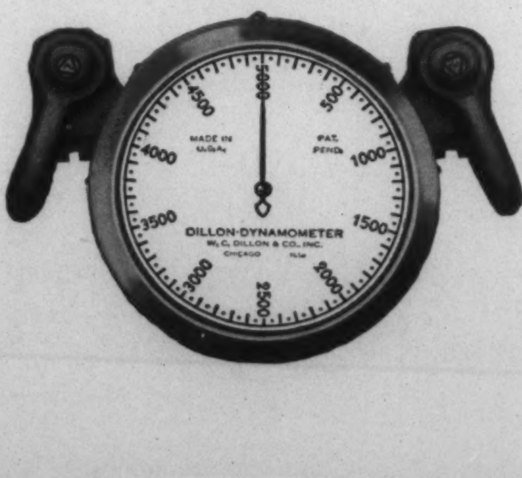
The new tester is pocket-size and light, and can be used for testing finished parts of almost any size or shape. A slight pressure against the surface to be tested gives a direct and instantaneous reading on the dial.



Skill in the use of the instrument is unnecessary, and it may be used in any position, according to the manufacturer.

Precision Dynamometers

Tensile strengths of rods, plates, welded materials, screws, cams, turnbuckles, cables, etc. as well as the stress in position on power, transmission, guy-strand and other wires, can be determined with the Dillon precision dynamometers, made by *W. C. Dillon & Co., Inc.*, 5410 W. Harrison St., Chicago.



The dynamometers are available in 2 general models—Model A, weighing 4½ lbs., can be had in one of seven capacities, from 2500 lbs. max. to 15,000 lbs. max.; Model B, weighing 1½ lbs., is available in 3 capacities, from 500 lbs. max. to 1,000 lbs. max. Prices range from \$50.00 to \$117.50.

Dillon dynamometers are used as the measuring instrument on the new Dillon tensile strength testing machine.

Spectrograph Photometer

A rapid and precise means of studying spectrographic plates is provided by a new photometer designed by Malpica and Fanter of *General Electric Co.*, Schenectady.

The instrument enlarges the spectral lines approximately 20 times, and determines their intensities by measuring the light passing through them to a photoelectric cell. The plate is mounted horizontally and all of the light-control devices and scales are immediately in front of the operator.

The equipment is arranged to operate on a 6-volt supply of either d.c. or regulated a.c.

New Sources for Inspection-Aids

A new supplier of radium for gamma-ray radiographic inspection of castings, forgings and other metal parts and structures is the *Canadian Radium & Uranium Corp.*, 630 Fifth Ave., New York. This company represents Eldorado Gold Mine, Ltd., of Toronto, whose high purity radium is now being offered the metal industries in approved containers for radiographic work.

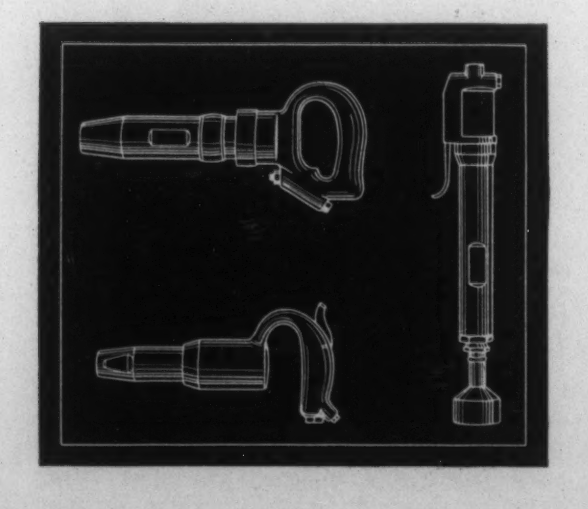
The Atlantic Instrument & Tube Co., Inc., 418 Broome St., New York, has just been organized for the manufacture of precision measuring instruments, adjustable snap gages and other tools. The snap gages are made to American Gage Design Standards, and are now in production.

(MORE NEWS ON P. 748)

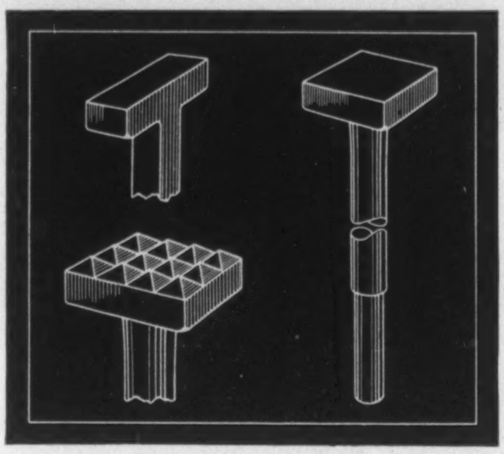
Technique for Ramming Refractory Mixtures in Place

Obtaining satisfactory service from a furnace lining is dependent upon two factors of equal importance. First is the proper selection of a suitable refractory material and secondly is a knowledge of the proper method to be used for installing the material in the furnace. Therefore, increased knowledge with respect to installation methods and developed skill in the art of installation will result in satisfactory service. The matter of suitable tools is an item which must not be overlooked.

Where the lining must withstand the action of chemically active slags, both from corrosion and erosion and, where metal penetration must be held to a minimum, density of lining and freedom from layer planes or cracks in the lining are essential. Many times the refractory material is condemned for failure in service, when actually the method of installation and not the refractory material is at fault.



Typical Pneumatic Hammers for Use in Ramming Linings

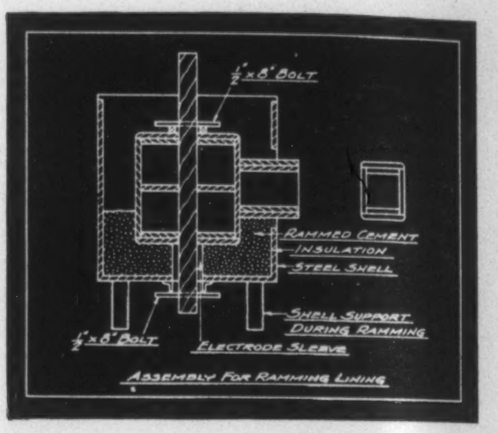


Commonly Used Shapes of Ramming Tools

For the best results, mechanical ramming should be employed. The use of mechanical equipment not only saves labor but if the ramming of the refractory lining is skillfully done, a much better job is obtained and longer service assured.

Proper installation of a rammed lining goes back to the preparation of the cement when it is received on the job. The refractory mixture should be prepared by the addition of sufficient water to make it workable and the whole thoroughly mixed, if possible, in a mechanical mixer. The amount of water to be added, usually about 4% by weight, can be quite closely determined by the feel of the mixed cement. If a handful of the mixed ramming cement is compressed firmly in the hand, the material should adhere in a firm lump.

Appreciable pressure should be required to break up this lump. The lump of material should shatter when breakage occurs.



Suggested Set-up for Ramming Lining in Rocking Type of Furnace

If the material is too dry, it will act like dampened sand. In other words, it will lack all semblance of plasticity. Under such conditions a lining will result which is porous and lacking in density. On the other hand, if the material is too wet, it will tend to "crawl" under the hammer and numerous layer cracks which will permit penetration of molten metal will result. It is in the avoidance of these two undesirable conditions that skill in application is important.

After a layer of cement, approximately 3" of loose material, has been rammed in place, the top surface of the layer just tamped should be thoroughly roughed up to a depth of approximately ¼" before the succeeding layer is applied. This will insure a good union between layers and minimize the danger of layer cracks in the finished lining.

REFRACTORY MATERIALS

Fused magnesia, which is especially suitable for melting metals, both ferrous and nonferrous in electric induction furnaces, has a melting point of 2350° Centigrade. It is exceedingly high in heat conductivity and electrical resistance. The coefficient of expansion is 0.0000135 cm. per degree Centigrade. It has a hardness of about six. It is furnished in various forms but usually as a cement composed of the refractory magnesia grains plus suitable ceramic bonding material.

Crystolon, or silicon carbide cements are particularly suitable for lining pit furnaces and crucible furnaces and for making monolithic linings and for general tamping operations. Crystolon cements can be made very dense and resistant to slag. They withstand thermal shock unusually well.

Alundum or fused alumina cements are stable under oxidizing and other chemical conditions, they provide very good heat transfer and their resistance to high temperature is excellent. The fused alumina used in the preparation of these cements has a melting point of 2050° Centigrade.

NORTON REFRACTORY CEMENTS

FOR RAMMING OR TAMPING

(Figures indicate approximate hardening temperatures)
Maturing temperature is the point at which sintering takes place

RA-889 — 1000° C. / 1830° F.
Burner block tamping cement

RA-1144 — 1000° C. / 1830° F.
Electric induction furnace linings
Brass alloy melting
Indirect arc furnace linings

RC-1132 medium fine — 1000° C. / 1830° F.
Monolithic linings
Patching

RC-1131 coarse — 1000° C. / 1830° F.
Pit furnace linings
Crucible furnace linings
Monolithic linings
Tamping

RC-1133 — 800° C. / 1460° F.
Patch cement
Pit furnace linings

RM-868 — 1200° C. / 2190° F.
Crucible linings

RM-1005 — 1200° C. / 2190° F.
RM-1114 med. coarse, RM-1118 coarse — 1200° C. / 2190° F.
Electric induction furnace linings in ferrous and nonferrous melting

RM-998, RM-1140, RM-1162 — 1200° C. / 2190° F.
Electric induction furnace linings
High copper alloy, cupro-nickel and leaded bronzes, silicon and aluminum bronzes

NORTON RESEARCH

Ingredient Number One in Longer-Lived Refractory Products

Refractory Shapes, Cements & Grains in
CRYSTOLON (silicon carbide); ALUNDUM (fused alumina); and Fused Magnesia

NORTON COMPANY, WORCESTER, MASS.

Magnesium-Fire Extinguisher

A new type of extinguishing agent to put out occasional magnesium fires in industry and to douse incendiary bombs (if that eventually develops) is announced by *Pyrene Mfg. Co.*, 560 Belmont Ave., Newark, N. J. The new substance is called "Pyrene G-1 Fire Extinguishing Powder", and was developed in conjunction with Dow Chemical Co., magnesium producer.

The new product is a dry inert compound that stops the combustion of magnesium as well as of other metals, such as sodium, potassium, etc.; it also contains material which, when heated, forms a heavy air-excluding, fire-smothering vapor.

The powder is applied to the fire by spreading it with a scoop or shovel, and is said to be capable of free use around machinery as it is non-abrasive.

The new product is said to fill a very urgent need since "the usual extinguishing agents have no extinguishing effect on burning magnesium alloys". However, approved fire extinguishers of the usual type are still needed to put out blazes in any nearby combustible materials ignited by the magnesium fire.

● A rotary or roll-type marking device with solid die, developed especially for marking shells or other ordnance units, indexing rolls, etc. during production on automatic machines is now available from *New Method Steel Stamps, Inc.*, Detroit.

Atomic-Hydrogen Arc Welders

General Electric Co., Schenectady, N. Y., announces that 35- and 75-amp. atomic-hydrogen arc welders of improved design at prices reduced approximately 15% have recently been made available. Such welders are used in industry for repairing tools and dies; for filling in flaws or blow-holes in steel and bronze castings; and for the fabrication and repair of hard-to-weld metals.

Instead of the transformer and reactor used in previous units, the new welder has a specially designed reactive transformer which combines the functions of both transformer and reactor. The weight of the welder has thereby been reduced more than 30%, and electrical characteristics improved.

Built-in power-factor correction, a feature of the new welders, helps to reduce installation cost and avoid power-factor penalties. Fan-forced ventilation provides cool operation, even at high currents or on high-duty cycles.

● New rivet washing tips developed by *National Cylinder Gas Co.*, 205 W. Wacker Dr., Chicago, are accurately machined from hard-drawn copper, with the preheat-orifice/oxygen-cutting orifice ratio such that maximum speeds are obtained for these operations. This oxygen-cutting equipment is useful for washing out rivet heads, removing frozen nuts and bolts, removing minor defects in castings and making gougings.

Electric Metal-Spray Gun

Most metal-spraying (metallizing) guns used for melting a metal wire and spraying the molten metal on surfaces to be built-up, repaired or protected employ a gas flame to melt the metal. A new metal-spray gun has been developed, however, which utilizes an electric arc for melting the wire, and thus eliminates the use of fuel gases and permits the spraying of refractory metals like tungsten, molybdenum, etc.

The new gun was developed by M. U. Schoop of Switzerland, who is represented in the United States and Canada by *Herman A. Holz,* 116-118 W. 14th St., New York. The electric gun is claimed to be 2½ to 10 times faster in output than the older Schoop gas-flame gun, and in many cases prior sand-blasting can be obviated. The new process is said to produce a much stronger bond than the old.

The Schoop electric-gun, in working with No. 18 B. & S. gage zinc or steel wire, requires 50 volts, 150 amps, a.c. or d.c.; with No. 15 B. & S. gage wire, 200 amps.

● *A. M. Byers Co.* will enter the field of alloy steel manufacture about June 15th, when its new electric furnace equipment will be placed in initial operation. The country's alloy steel capacity will thereby be increased another 30,000-40,000 tons a year.

Some Plastic Substitutions

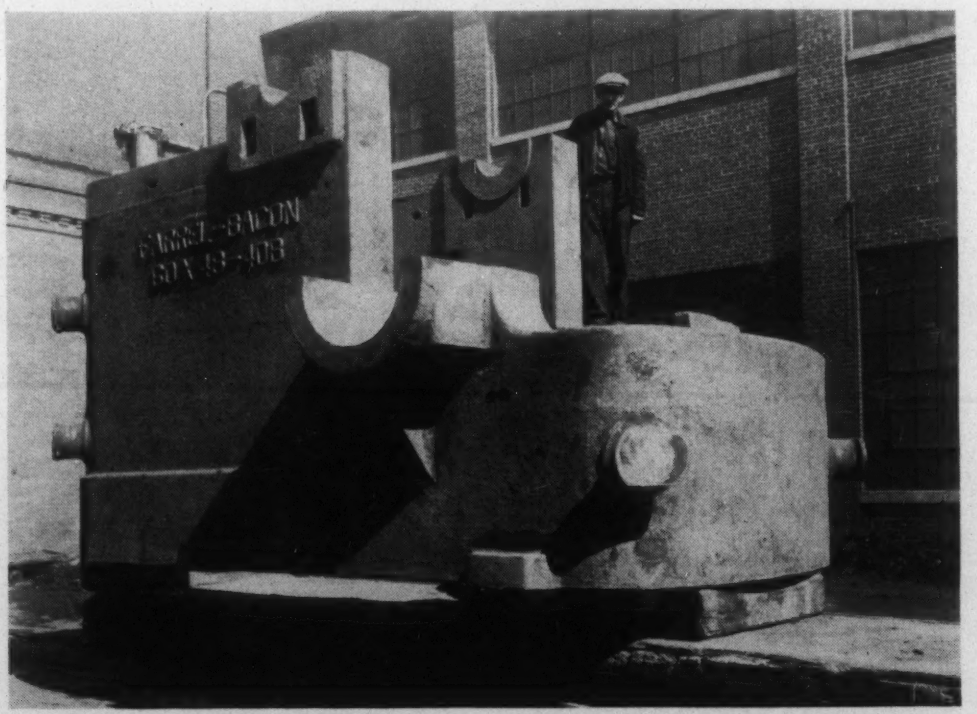
Editorials in recent issues of METALS AND ALLOYS have urged metal-consumers and metal-producers to cooperate in finding satisfactory substitutes for metals urgently needed for defense, and have outlined the present and future position of plastics in this respect. Design changes along these lines in peace-time products have already been widely introduced, and the 2 cases cited below are typical of many.

Aluminum or brass gage dials formerly used by the *Ashcroft Gauge Div.* of *Manning, Maxwell & Moore, Inc.*, Bridgeport, Conn., have been replaced with a new plastic gage dial. The makers claim that the new plastic dial not only will save significant amounts of aluminum but is actually superior to metal dials for it can be washed and will not warp, corrode or rust. The new dial is really a sandwich, with the dial graduations permanently sealed between layers of clear plastic.

Similarly, *H. S. Cover,* South Bend, Ind., has replaced all aluminum parts in "Dupor" twin filter respirators with plastics. Here again, the new construction is said to have advantages over the old, chiefly in dismantleability and lighter weight.

An interesting feature of both these developments and of several others is that the manufacturers involved regard the plastic design to have distinct advantages quite beyond a merely stop-gap function. This indicates that the post-emergency period will see very intense competition between formerly-used metals and their emergency substitutes, which will demand all the product-research and market-development that the manufacturers concerned can employ—starting now.

Large Stone-Crusher Casting



One of the largest castings ever made by *Farrel-Birmingham Co., Inc.*, Ansonia, Conn., is this 68-ton Meehanite iron casting, which forms the bed of a stone-crusher capable of reducing 4 ft. x 4 ft. x 5 ft. pieces of rock to crushed stone. Seventy-five tons of metal were melted for the casting, which was poured simultaneously from two large ladles and finished in a third smaller ladle.

Only ten minutes was required to pour the casting, which was then allowed to remain in the sand box two weeks for correct cooling.

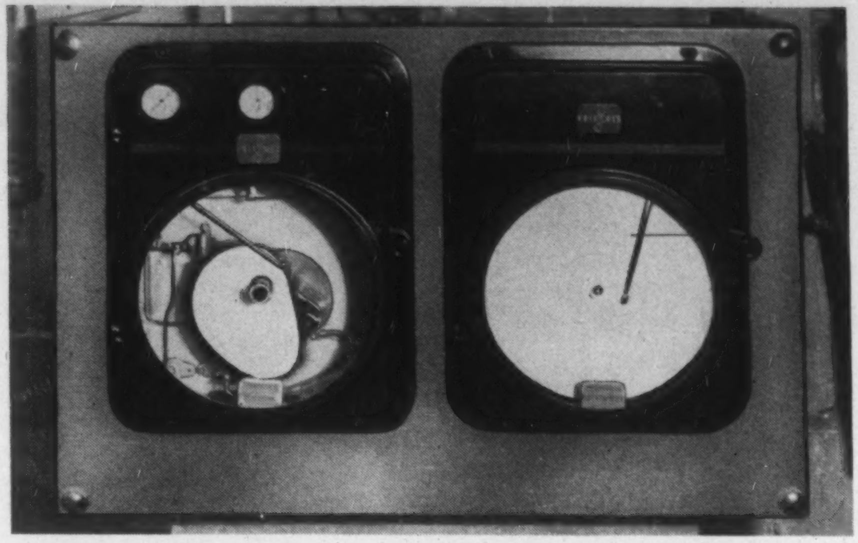
• • •

PYROMASTER HELPS CUT STRESS - RELIEF CYCLE FROM 100 to 40 HOURS

After final welding of assembled units, one of the largest producers of electrical goods formerly required 100 hours for stress-relief heat-treatment. Bristol's Pyromaster Time-Temperature Controller made possible a 60% saving in time, by regulating cooling stages precisely according to schedule.

MANY VARIETIES FOR DIFFERENT NEEDS. Actually, Bristol's sensitive, practically maintenance-free Pyromaster is offered in six different top-notch potentiometers — models merely indicating, merely recording, recording-indicating, and controlling in three different styles. WRITE TO 114 BRISTOL RD., WATERBURY, CONN., FOR BULLETIN 507.

TRADE MARK BRISTOL'S REG. U. S. PAT. OFFICE



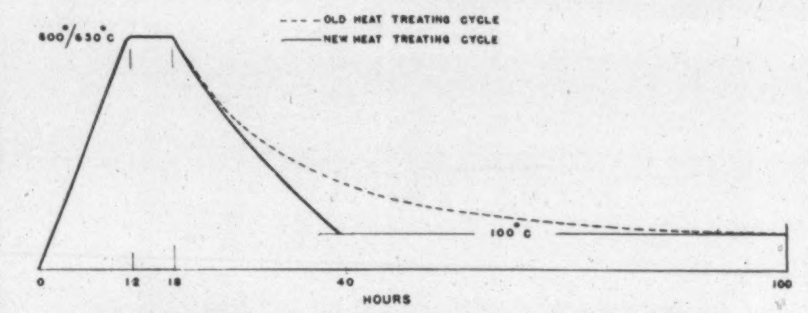


Fig. 9. Typical stress-relief cycle, showing saving in time accomplished through forced cooling

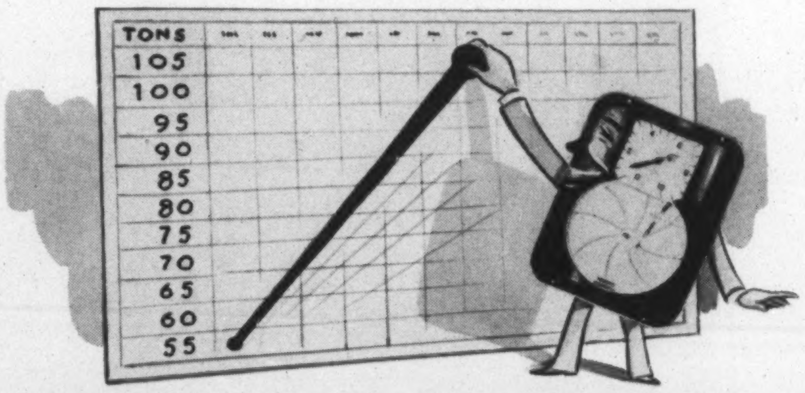
BRISTOL-CONTROLLED HOT BLASTS

Better Pig Iron
Less Labor and Fuel

With hot blast temperatures automatically controlled by Bristol's Pyromaster

- temperature in the smelting zone is made more uniform, maintaining constant quality, unvaried chemical composition of pig iron.
- furnace tender is freed from constant manual supervision, meaning less attention needed for a battery of blast furnaces.
- strains and stresses in blow pipes, tuyere stocks, bustle pipe linings are greatly reduced, lengthening their life, slashing maintenance costs.

TRADE MARK BRISTOL'S REG. U. S. PAT. OFFICE



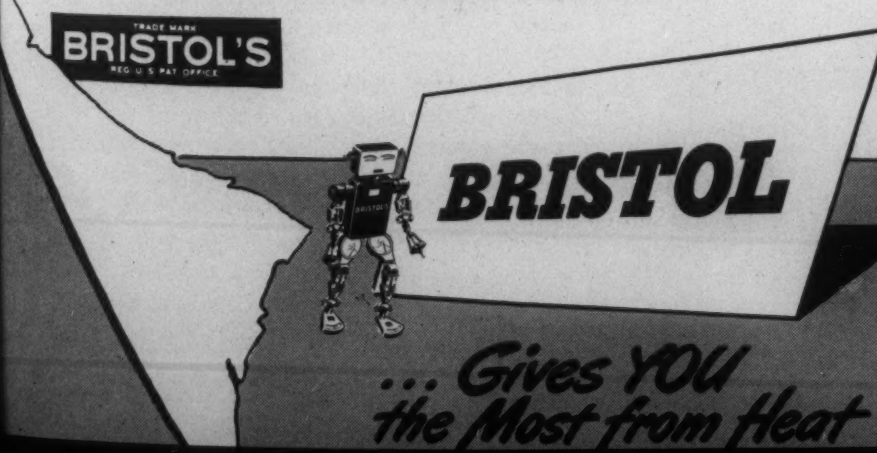
PYROMASTER REPLACES ON-AND-OFF POTENTIOMETER, UPS FURNACE OUTPUT 81.6%

On furnaces for bright annealing steel strip and wire, the on-and-off potentiometers formerly used resulted in widely varying flame length, inconsistent and inefficient heat input in preheating cell, unnecessary stresses on refractories. In place of those potentiometers went a coordinated set of 3 Air-Operated Pyromasters and a Process Cycle Controller.

RESULTS . . . FROM SAME FURNACES

	Tons per week			Average, 3 pairs of weeks
Old control	61	54	59	58
Pyromaster control	112	91	113	105⅓
Percent increase with Pyromaster	83.6%	68.5%	91.5%	81.6%

TRADE MARK BRISTOL'S REG. U. S. PAT. OFFICE


BRISTOL
... Gives YOU the Most from Heat

THE BRISTOL COMPANY
WATERBURY, CONNECTICUT
THE BRISTOL CO. OF CANADA, LTD.
Toronto, Ontario
BRISTOL'S INSTRUMENT CO., LTD.
London, N.W. 10, England

AUTOMATIC CONTROLLING AND RECORDING INSTRUMENTS

● To meet the demand for batch or continuous operation at 100-250 lbs.-per-hr. capacities, a small magnetic separator (type KB) with a powerful, intense magnetic field for extracting the tiniest iron particles from powdered vitreous enamel, etc. has been designed by *Stearns Magnetic Mfg. Corp.*, Milwaukee.

● A small, inexpensive etcher for permanently marking new small tools and parts writes with an exceptionally fine line, the etcher tool being held and used like an ordinary lead pencil, according to *Ideal Commutator Dresser Co.*, 1928 Park Ave., Sycamore, Ill.

Steel Blackening Process

A blackening process for steel parts, described as rapid, controllable and durable, is being offered by *E. F. Houghton & Co.*, Philadelphia. The basis of the process is Houghto-Black—a salt that is mixed with water, with the solution held at the boiling point (around 290 deg. F.) while the parts to be blackened are dipped in it.

Only a few minutes' immersion is required as compared with the old browning and rusting process. Parts are chemically cleaned before immersion and carefully rinsed after. The lustrous black finish is provided without any effect on dimensions.

● A 400-ton C-Frame hydraulic press that combines the main ram, rapid traverse cylinder and a stripper cylinder operating through the bolster has recently been completed by *Denison Engineering Co.*, Columbus. The frame is constructed of welded steel plate, annealed and normalized after welding.

Plating Tank Instrumentation

The development of a new system of instrumentation for plating tanks is announced by *Brown Instrument Co.*, Philadelphia. The system involves direct control of the temperature of the water circulated through coils or water jackets, rather than indirect control of the circulating water from the temperature of the plating solution.

The new system is claimed to maintain a uniform plating temperature, to save on steam and cold water through the closeness of temperature control, to provide longer life for the control thermometer because it is not immersed in the plating solution, etc. The importance of maintaining uniform plating temperatures is obvious to all plating engineers.

Circular Chart Potentiometer

A circular chart potentiometer, described as a new type of self-balancing instrument for indicating and recording temperature, is announced by *Brown Instrument Co.*, Philadelphia.

The new pyrometer employs the established null-point potentiometer measuring circuit, but its balancing system is said to be entirely new and different.

The balancing system is continuous and has no galvanometer. It is described as unique in speed of response and extremely sensitive to minute temperature changes.

Sensitivity may be adjusted for any standard pyrometer range, thus making all amplifiers interchangeable. Its ruggedness is said to be of especial importance from the viewpoint of shop operating accuracy.

● For use on shear bolts where a high degree of the stress is lateral, and for general application to light- and medium-stress fastenings, an improved line of thin hex nuts is announced by *Elastic Stop Nut Corp.*, 2332 Vauxhall Rd., Union, N. J.

BALANCE

—the secret of FASTER, BETTER SOLDERING

There's never any hit-and-miss about using Kester Cored Solders! You are assured of positive flux control . . . the proper solder and flux, both as to *kind* and quantity . . . scientifically *balanced*, at the factory.

This does away entirely with guesswork . . . no dipping a swab in a messy flux-pot and smearing the work with excess acid. There's no waste of flux or damage to the work, due to corrosive reaction, when Kester Cored Solders are used.

Faster, better soldering and lower production costs result. That's why Kester Cored Solders are "STANDARD FOR INDUSTRY."

Consult Kester about any shop problem involving solder. Find out whether better results with Kester Cored Solders can increase the profits of your business.

KESTER SOLDER COMPANY
4219 WRIGHTWOOD AVENUE CHICAGO, ILLINOIS
Eastern Plant: Newark, N. J.
Canadian Plant: Brantford, Ont.

KESTER CORED SOLDERS
STANDARD FOR INDUSTRY

Electrode-Pressure Gages

An electrode pressure gage designed to measure the pressure between the electrodes of resistance-welding machines has been announced by *General Electric Co.*, Schenectady, N. Y. It can be used for checking existing gages or pressure indicators on spot, line or projection welders, or for checking electrode pressure when setting-up for production.

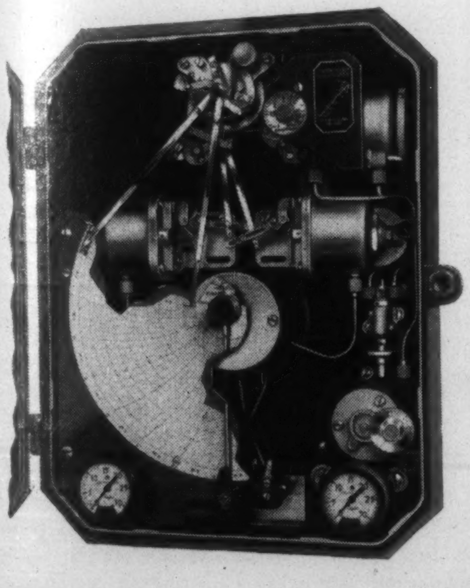
The new gage measures pressures from 0 to 4500 lbs., with an automatic safeguard against overload. No jigs or other auxiliary equipment are needed to apply it to existing welding machines.

In use, the gage is inserted between the electrodes so that they press on the pads on the top and bottom of the gage yoke. The electrode pressure is adjusted until the desired pressure is registered on the direct-reading dial, the gage is withdrawn, and the welding machine placed in operation.

Ratio Controller

An adaptable, easily convertible instrument for applications where a temperature, pressure, rate-of-flow or liquid-level must be controlled in a desired ratio to another variable is now offered by *Taylor Instrument Cos.*, Rochester, N. Y.

With the new direct-setting Taylor ratio controller, the ratio is changed by a simple screwdriver adjustment directly on a calibrated dial throughout the range of 0/1 to 3/1, direct or inverse. It is unnecessary to disturb the processing or to remove the chart plate while making adjustments.



The new ratio controller may have one of two measuring systems—an adjusting system that indicates or records only, or a controlling system that may either indicate or record. Both models are available with all the features of the 120-R series Fulscope.

● *Lindberg Engineering Co.*, manufacturers of heat treating furnaces and equipment, has recently moved into a new $250,000 plant, located at Campbell & Hubbard Streets, Chicago.

Surface Hardening Stainless Steel

A processing service for surface hardening 18 and 8 stainless steel, known as "Super Scottsonizing," is announced by *C. U. Scott & Son*, Rock Island, Ill. According to the company, the process applies a 0.005 in. case on a finished part without warpage, and without destroying the stainless qualities of the steel. It is said to be applicable to all wearing parts that can be finished to size on the surface desired hard.

Cases up to 650 Brinell hardness can be produced, it is claimed, and dimensional tolerances may be held to within 0.0002 in. The case, it is said, will not crack or spall, and will stand a temperature of 1000 deg. F. and still return to its original high hardness when cooled.

The process is available to any manufacturer who will send parts for treatment, prices being comparable to hardening prices of high carbon, chromium and tungsten steels.

● The coated aluminum-bronze welding rod produced by *Ampco Metal, Inc.*, Milwaukee (and described in the Nov., 1940 issue of METALS AND ALLOYS, p. 654) has been renamed "Ampco-Trode". The new welding rod features high-strength and wear resistance and suitability for all welding methods.

The prospects for Forty-Niners...

TODAY

THE INDIUM CORPORATION OF AMERICA · Pioneers In. element 49

We have struck a bonanza! And staked our claims for INDIUM, the 49th element in the atomic scale—which we, The Indium Corporation of America, have pioneered from a laboratory toy, exceedingly rare, fabulously expensive, and practically unknown—and have developed as a commercial metal with many uses for Industry.

INDIUM, alloyed, or plated and diffused by our patented process, with non-ferrous metals such as cadmium, copper, lead, tin, silver, zinc, etc. is definitely established as the necessary coefficient for the solution of many of the urgent problems facing Industry today.

Our patented diffusion process is unique. It is the final process *beyond* other electroplating methods, which only deposit a veneer upon the base metal. Diffusion, by our patented process, *fuses* and *integrates* INDIUM with the base metal to effect an actual alloy for the surface—with much greater immunity to chipping or peeling and greater resistance to wear and corrosion.

Necessity makes pioneers! Today you have the opportunity to be forty-niners with us. In your own plants and laboratories test INDIUM, the forty-ninth element, in your product. We supply INDIUM at $1.00 per laboratory gram. Adequate supply and prompt delivery prevent production delays. Informative literature and laboratory sample grams may be obtained from our New York office.

THE INDIUM CORPORATION OF AMERICA
Research and Development Office
60 East 42nd Street, N. Y. C.

Please send ______ grams of INDIUM for experimental use at $1.00 per gram. Check or money order attached.
Please send me informative literature about INDIUM.
Name ______________________
Address ______________________

THE INDIUM CORPORATION OF AMERICA

Research and Development Office
60 East 42nd Street, N. Y. C.

Sales Office and Laboratory
805 Watson Place, Utica, N. Y.

Crimped Designs in Bonded Metals

Several interesting new crimped designs in bonded "pre-finished" metals have recently been introduced by *American Nickeloid Co.,* Peru, Ill.

One of these, a "7/16 in. crimp", is available in horizontal, diagonal, square and diamond patterns in a variety of metal thicknesses, and in sheets up to 24 in. x 36 in. Another—the "oval crimp"—is available in 1/8 and 3/16 in. widths as continuous coils of strip in gages from 0.010 in. to 0.015 in.

Both are offered in bright or satin finishes of nickel, brass, chromium or copper electro-bonded to steel, zinc or brass. The oval crimp is highly adaptable for inlay purposes, and the 7/16-in. crimp is offered for reflectors, stove pads, electric appliances, signs, etc.

Bright Copper Plating

Pressure on the nickel supply has engendered much interest in plating practices involving bright, heavy copper deposits followed by relatively light nickel coatings. A new bright copper plating process for such work has been developed by Dr. Louis Weisberg and is being marketed by *Hanson-Van Winkle-Munning Co.,* Matawan, N. J.

The basic ingredients of the solution are copper sulphate, diethylene triamine and ammonium sulphate. The average current density is about 40 amps./ft.^{2} and a moving cathode is recommended. Anodes are preferably of electrolytic copper, although cast copper anodes may be used.

Rubber-lined equipment is required. Before plating with the process on zinc or steel, a cyanide copper "flash" is required.

● A new clear polymerized adhesive oil claimed to have high lubricity and to stay efficient 3 to 10 times longer than other oils is offered by *L. R. Kerns Co., Inc.,* 2827 E. 95 St., Chicago, for heavy-machinery lubrication.

Meetings and Expositions

AMERICAN ELECTROPLATERS' SOCIETY, annual convention. Boston, Mass. June 9-12, 1941.

EASTERN PHOTOELASTICITY CONFERENCE, semi-annual meeting. Cambridge, Mass. June 12-14, 1941.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer convention. Toronto, Ont., Canada. June 16-20, 1941.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, semi-annual meeting. San Francisco, Calif. June 16-20, 1941.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, semi-annual meeting. Kansas City, Mo., June 16-20, 1941.

HEATING, PIPING & AIR CONDITIONING CONTRACTORS NATIONAL ASSOCIATION, annual meeting. San Francisco, Calif. June 16-20, 1941.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting. Chicago, Ill. June 23-27, 1941.

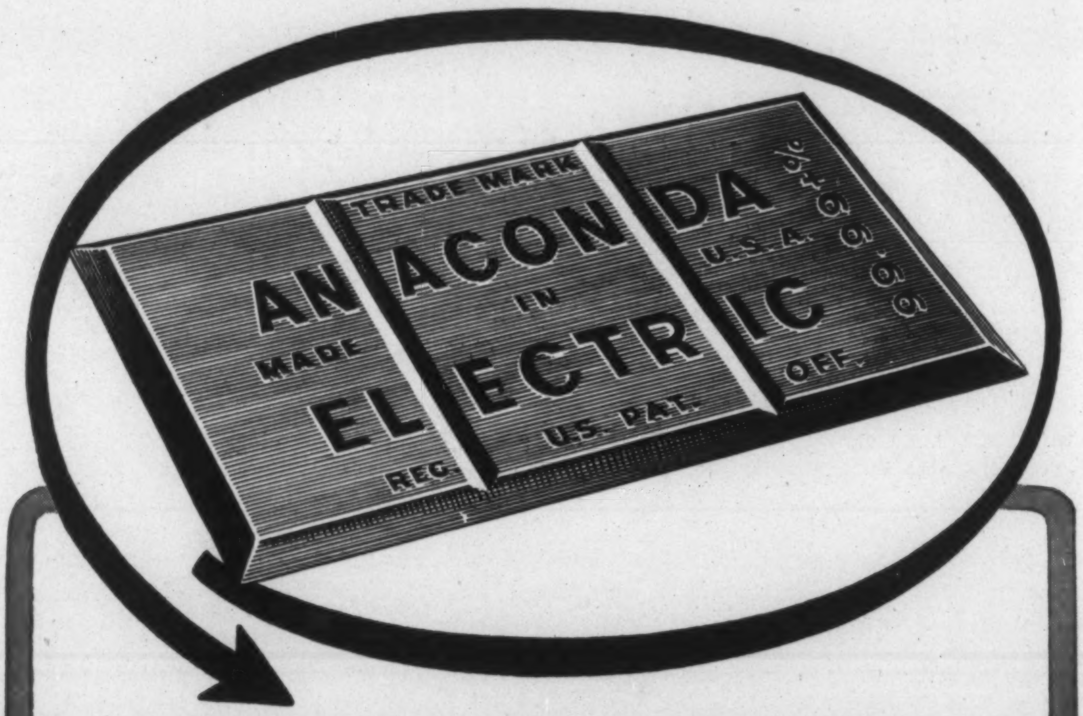
AMERICAN SOCIETY OF CIVIL ENGINEERS, annual convention. San Diego, Calif. July 23-25, 1941.

New Strip-Chart Recorders

A newly-designed strip-chart recorder is now offered by the *Bristol Co.,* Waterbury, Conn. Many changes have been made in the construction of these new instruments, including the case design, chart drive, measuring elements and writing mechanism.

They are available for recording on a 6-in. strip chart d.c. volts and millivolts, d.c. amperes and milli-amperes, pressure, liquid-level, flow, temperature, motion, and for remote recording, using Bristol's Metameter system of Telemetering.

● *Ingersoll-Rand Co.,* Phillipsburg, N. J., has just announced a new line of portable air compressors with engines convertible from gasoline to oil or from oil to gasoline, and claimed to reduce average fuel costs considerably as compared with previous models of the same company.



Special High Grade
99.99+% ZINC

To producers and users of zinc die castings, we say simply this: *Specify Anaconda Electric,* for you may be sure that every slab is of uniform high purity. Electrolytic refining does it. 39392

Shipping Point: Great Falls or Anaconda, Montana

ANACONDA
from mine to consumer

ANACONDA SALES COMPANY
25 Broadway, New York
Subsidiary of Anaconda Copper Mining Company

Corrosion Resistant Paints

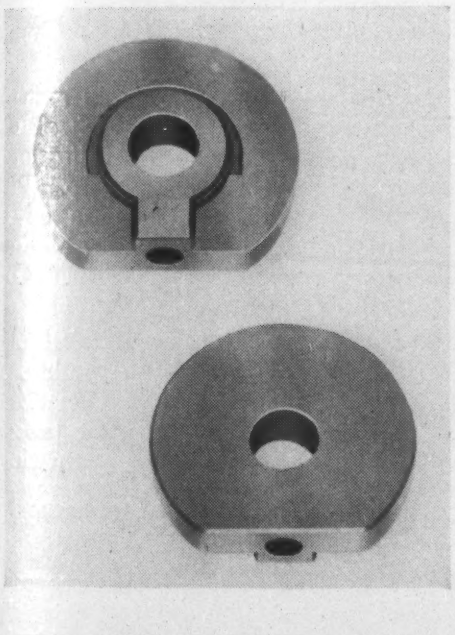
As a companion product to their "Tygon" linings (described in our March, 1941 issue, page 312), *U. S. Stoneware Co.*, Akron, Ohio, has developed an all-purpose paint for general industrial use.

The new Tygon bath is specially recommended by the manufacturer for service requiring a highly corrosion-resistant coating—for process industries equipment; on containers, walls, etc. of plating, pickling and etching departments; on laboratory walls, benches and tables; and for general protection against acid spillage and highly corrosive fumes.

The new paint is resistant to the strongest mineral acids, it is said, and to all plating and pickling solutions. It comes in a wide range of colors and adheres firmly to concrete, wood or steel.

Porous Bronze Bearings

Several new shapes and sizes of "Selflube" porous bronze bearings have recently been developed by *Keystone Carbon Co.*, 1935 State St., St. Marys, Pa. The illustration shows top and bottom views of one of these designs.



Such bearings are made from powdered alloys, molded to shape, sintered, and quenched in oil. Their porosity (averaging 35%) permits internal storage of a large amount of oil, which is continuously fed to the surface during bearing service.

"Selflube" bearings have a tensile strength of 35,000 lbs./in.^{2} and will carry heavy loads without distorting or breaking, it is said. They are molded to close dimensional tolerances so that no redesigning or special engineering is required.

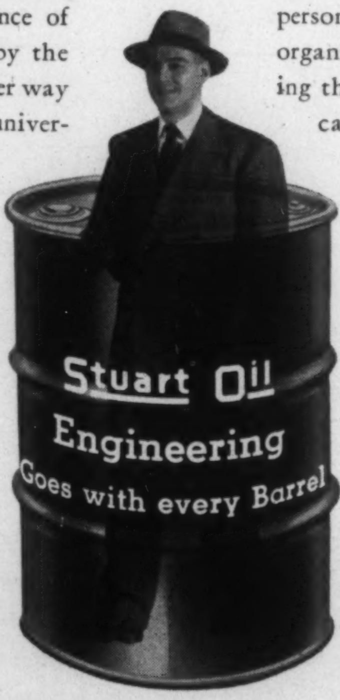
Friction Materials from Powdered Metals

A new all-metal friction material, consisting of a combination of pressed and sintered powdered metals welded to a steel support backing and known as "Velvetouch," is a product of *S. K. Wellman Co.*, 1381 E. 49th St., Cleveland. Bi-metallic friction materials of this type are manufactured for all types of trucks, tractors and industrial machinery, for which they compete directly with conventional friction materials.

Thus, these sintered products are claimed to be used in place of asbestos in auto, truck, tractor and industrial machinery clutch-facings, and in place of copper and brass in machine tool clutches; in place of leather and wood in printing machinery; in place of felt on tension controls for wire drawing and paper mill machinery, etc.

The materials are available in several types, among them riveted-on disc-type facings, sandwich-type disc facings, external contracting-type linings, and internal expanding-type linings. Even airplanes use the sintered facings—Velvetouch brake discs are employed, it is said, in disc-type airplane brakes and elsewhere.

● A system for controlling the fuel feed rates of regenerative furnaces is announced by *Brown Instrument Co.*, Philadelphia. The system automatically maintains a fuel rate at the desired value and thus aids steel-plant engineers in obtaining maximum over-all furnace efficiency.



ARE YOU OVERLOOKING THIS POWERFUL PRODUCTION TOOL?

The problems of increased production are so many and varied that simple solutions are often hidden and difficult to perceive.

Obviously, it is necessary to squeeze every ounce of production efficiency from existing tools and machines. This can best be accomplished when cutting fluids are seriously recognized as a factor of prime importance. Perhaps you have overlooked the useful developments in the field of cutting fluids that have accompanied improved machine and tool designs. The importance of such developments is evidenced by the interest in intensive research under way in the laboratories of leading universities and machine tool manufacturers.

When a plant door is unwittingly closed to the results of scientific progress in the field of cutting fluids and cutting fluid applications, its production executives are neglecting to use a valuable and immediately available working tool.

As a production executive interested in getting more out of existing tools and machines, by eliminating such superfluities as tradition, reciprocity, etc., will you consider the following suggestions? They may solve your problems.

WHAT YOU CAN DO ABOUT IT!

1. Encourage your purchasing agent to consider bona fide new cutting oil developments. Ask him to open the door wide to the qualified vendors possessing the all important credential of well founded information on the lubrication problems of today.
2. Remind your factory manager, superintendent or test engineer that the policy of trying out well recommended cutting oil products can be of vital importance and may quickly open up bottlenecks in the road to increased production.
3. Suggest to your metallurgist that machinability troubles can frequently be cured by getting the right cutting oil to fit the job, preferably selecting one with a sufficient factor of safety to provide for occasional metallurgical irregularities.
4. Inform your tool engineer that when deliveries of small tools are slow or difficult to obtain, it may be that the opening of the door and the help of a qualified cutting oil engineer may prolong the life of the tools on hand, thereby reducing appreciably this particular bottleneck in a quick and simple way.

WHAT WE CAN DO ABOUT IT!

1. We can through an informed and alert personnel immediately present to your organization timely information covering the most efficient cutting oil applications for ALL metal cutting operations. At the present time the problems involved in the manufacture of gun barrels and mechanisms, military tanks, ammunition, airplane engines and other similar items are, because of the emergency, particularly important.
2. We can present to you complete cutting oil research facilities, together with broad practical experience gained from working hand in hand with the manufacturers of small tools, builders of machine tools and makers of alloy steels.
3. We can give you the benefit of years of experience in supplying cutting oil products and cutting oil engineering service to the largest consumers in the most highly competitive industries. We are today providing government manufacturing plants (armories and arsenals), airplane engine builders, and the earlier manufacturers of munitions with a quality of cutting oil products and a specialized cutting oil application service that saves tools and speeds up production.

YOU OPEN THE DOOR—WE WILL SERVE YOU WELL

D. A. STUART OIL CO.
LIMITED • Est. 1865
2727-2753 SO. TROY STREET • CHICAGO, ILL.
Warehouses in Principal Metal Working Centers

● A new carbide tool grinder using 6 in. silicon-carbide or diamond wheels and featuring heavier machine-tool type of construction, has been placed on the market by *Hammond Machinery Builders, Inc.*, 1646 Douglas Ave., Kalamazoo, Mich.

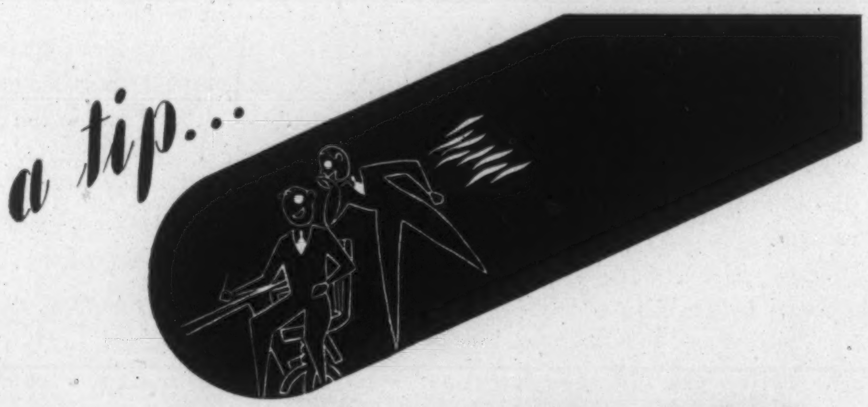
Light Steel Housings

A new patented all-steel housing known as Lindsay Structure has recently been announced by *Lindsay Structure Div.* of *Dry-Zero Corp.*, Merchandise Mart, Chicago. In it the panel sheets are "pre-tensed" to reinforce the framing members. Cross braces, gussets and struts are unnecessary, and light sheets and framing can be used without sacrificing rigidity.

Sheets and framing are fastened without rivets or welds, and can be assembled or disassembled with small wrenches.

Lindsay Structure is available in plain, Galvannealed or enameled finish, and is offered for furnace housings, driers, air conditioning housings, truck bodies, marine and railroad uses, etc.

● Patent licenses to manufacture and sell "Zoop" self-emulsifying degreasing solvent concentrate, formerly owned by Johns-Manville Automotive Div. have been acquired by *Bennett Corp.*, Cambridge, Mass.



TO ELECTRODE BUYERS

ORDER ELECTRODES WHEN YOU ORDER STEEL!

Electrode manufacturers, along with many others having a part in defense production, are faced with the problem of maintaining the prompt deliveries to which customers are rightfully entitled.

Because of these conditions we earnestly urge all users of electrodes *to order electrodes when they order their steel.* Requirements are generally known at that time and by ordering without delay embarrassing delays due to electrode shortages may be avoided.

The unprecedented increases in industrial production make it essential that welding speed be stepped up to the maximum. The Murex engineering department, with its wide experience in shop practices and welding procedures, will be glad to consult with you. No obligation.

MUREX HEAVY COATED ELECTRODES

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THERMIT WELDING — STANDARD FOR 40 YEARS FOR WELDING RAILS AND HEAVY EQUIPMENT

News of Metallurgical Engineers

The American Foundrymen's Assoc. at its annual meeting last month elected *H. S. Simpson,* president of National Engineering Co., as its president, and *Duncan P. Forbes,* president and general manager of Gunite Foundries Corp., as its vice-president. New directors are *L. N. Shannon, M. J. Gregory, W. J. Corbett, J. G. Coffman* and *R. J. Allen.*

Anthony J. Chenis has joined the Bullard-Dunn Process Div. of the Bullard Co., Bridgeport, Conn., in charge of the laboratory. . . . *John D. Sullivan,* chief chemist of Battelle Memorial Inst., Columbus, Ohio, has been elected chairman of the Electrothermic Division of the Electrochemical Society.

Schuyler Herres is making, at Battelle Memorial Inst., a study of available information on cupola design and operation for the American Foundrymen's Assoc.... Also at Battelle, *L. H. Grennel* has been engaged for the development of improved copper alloys and other products for industrial application.

D. T. Flater, until recently works manager of the Chrysler-Jefferson plant, is now general master mechanic of Chrysler Corp., Detroit. . . . *W. L. Ludwick* has left Farnsworth Television & Radio Corp. to become chief engineer of the instrument division, Thos. A. Edison, Inc., Orange, N. J.

P. E. Sance is the new works manager of Allenport Div., Pittsburgh Steel Co., Pittsburgh. . . . *H. W. Graham,* director of research, Jones & Laughlin Corp., Pittsburgh, has been named chairman of the Committee on Iron & Steel of the National Research Council's South American Committee.

J. L. Christie is now metallurgical manager, Handy & Harman, New York. . . . *W. C. Pinkerton* has resigned from *Chemical Engineering Catalog* to edit process-industries house-organs of the International Nickel Co., Inc., New York.

● For grinding chip-breaking grooves in carbide metal-cutting tools, a new chip breaker grinder (Drafto Model A) has been developed by *Drafto Co.,* 195 Walnut St., Cochranton, Pa. A design feature is the simplification of correct tool adjustment to any desired angle.

Contacts for Aircraft Switches

A good example of the materials-problems faced and solved by metallurgical design engineers is the selection of electrical contacts for aircraft battery transfer switches.

Thus, the Automatic Switch Co. needed contacts to handle 200 amps. at 24 volts d. c. without roughening (as fine silver contacts would, it is said). "Gibsiloy" silver-nickel contacts, made from powdered metals by *Gibson Electric Co.,* Pittsburgh, were ultimately chosen, because they approach pure silver in conductivity, yet retain a smooth, unpitted contact surface in operation. This assures low operating temperatures for a long time, it is stated.

New Tempering Furnaces

A new tempering furnace for tool room tempering, heat treating aluminum rivets, castings and parts, pre-heating of aluminum billets before forging, heat treating magnesium alloy castings and other work requiring temperatures of 300-1200 deg. F. is announced by *Despatch Oven Co.*, Minneapolis, Minn.

The new furnace (type CF) features a heavier body construction than its predecessors and heavy-duty lift doors in place of the former swing-type doors. The standard furnaces in this line range from 13 in. x 13 in. x 13 in. to 37 in. x 37 in. x 25 in. and are available with either gas-fired or electric heating systems.

FREE SERVICE DEPARTMENT

Replies to box numbers should be addressed care of METALS AND ALLOYS, *330 W. 42nd. St., New York.*

HELP WANTED: Young graduate metallurgist with practical knowledge of the processing of stainless steels. Should be experienced in the investigation of metallurgical problems of stainless steels in production and development. State training, experience and salary. Box MA-12.

HELP WANTED: Young metallurgical or mechanical engineer graduate qualified for general and research machinability work on stainless steels. Some knowledge in operation of machine tools desired. State training, experience and salary. Box MA-13.

POSITION WANTED: Non-ferrous mill superintendent, American, 37 years of age with 21 years of practical experience, good education, fine background. Good experience in newer alloys. Box MA-14.

HELP WANTED: Young engineer with broad knowledge of metals, together with pronounced aptitude for technical writing, for editorial position with metal publication. Give all pertinent data, including salary required. Box MA-15.

An
INDEX
to the contents of
"METALLURGICAL ENGINEERING DIGEST"
for 1940
is now available.
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Plastic Coating for Metals

A plastic coating for metals, known as Marlox, is being introduced by *Marley Chemical Co.*, 983 E. Milwaukee St., Detroit. The new coating is said to be of the structural type and is used more for its toughness and durability than for glamour.

The product is used either as a priming coat or for external protection against rust and corrosion. Chief among the advantages claimed for the new coating is its very low index of porosity as compared with coatings made from oils and pigments.

● Ready-mixed cutting oils for drilling, reaming and rifling gun barrels for small arms—.30, .45 and .50 caliber—are now being supplied by *E. F. Houghton & Co.*, Philadelphia.

● A new development in "pre-finished" metals is the availability of nickel- or chromium-plated aluminum sheets, reports *American Nickeloid Co.*, Peru, Ill. Such pre-finished sheets require no plating or polishing by the user, who may stamp, form, bend or moderately draw them without harming the mirror surfaces.

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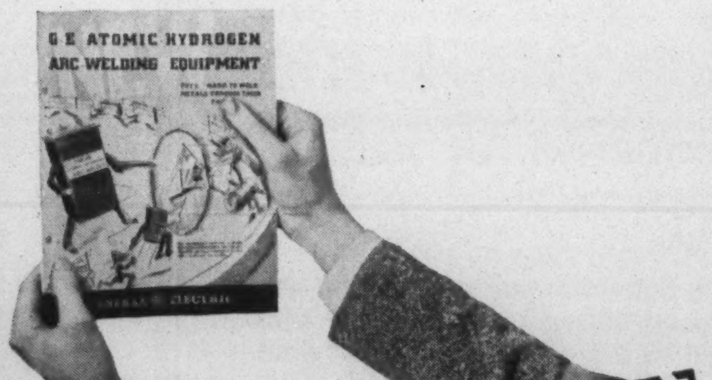

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ON MILD STEEL

Where especially ductile and homogeneous fusion-welded joints are required on mild steel, *atomic hydrogen* does the job better and quicker than any other process. Its precise and accurate control of heat is especially good on thin material in making smooth joints, free from "pin holes" and undercutting.

ON SPECIAL ALLOYS

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GENERAL ELECTRIC

METALLURGICAL ENGINEERING shop notes

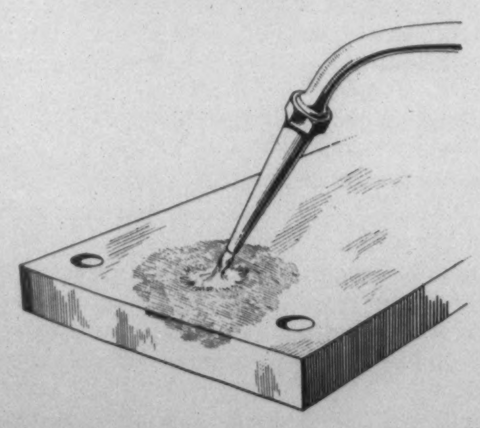
Localized Flame Annealing

by R. B. Seger
Lindberg Steel Treating Co.

Very often in the manufacture of steel parts it is discovered after hardening has been completed that a hole has been left out, or a keyway forgotten, or the bore should have been left soft, etc. In such cases, it is not always necessary to anneal the whole part and reharden, or even to junk the article.

Localized or spot annealing with an oxyacetylene torch is a convenient and economical means of saving the part, particularly if it is carburized steel. Although a tricky procedure, flame annealing of a restricted area can be mastered with but a few hours of practice.

Usually an operator on his first attempt at spot annealing ends up with the portion to be annealed harder than the rest of the part. This is because he heats the spot up to or above the critical range and then, when the torch is removed, the heat is rapidly extracted by the cold section underneath, giving the same effect as a quench. This is particularly true of steels of high nickel content, with their air-hardening tendencies. It is, therefore, usually best to heat to just below the critical, ordinarily between 1200 deg. and 1325 deg. F., and the treatment may thus be classed as a high-temperature draw rather than an anneal.



Because of the difficulty in seeing the exact temperature directly beneath the cone of an oxyacetylene flame, temper colors must be used. This means the part must be prepared to make the temper color visible. The two best ways of preparing for color are polishing with emery cloth or grinding wheel, and sandblasting, the latter being preferable.

In order to see color at exactly the right moment, the oxyacetylene flame must be adjusted to be oxidizing. *Never have a reducing flame.* The flame should be adjusted, by adding oxygen, so that there is a sharp blue-colored cone at the tip of the torch.

If the flame is now placed so that the sharp end of the cone is approximately ⅛ in. from the article, after about 3-8 sec. (depending upon the size of the part), a deep blue ring will appear approximately ½ in. to ¾ in. from the cone. These distances are those obtained with a No. 6 tip; the size of the ring of blue will vary with the size of tip. As soon as this blue ring is seen, the torch must be removed.

If the portion to be annealed is long the procedure is the same except that the torch must be moved along the surface at a constant sped. The ring of blue should precede the cone approximately ½ in. to ¾ in. also, according to the size of tip. It will be noticed that immediately at the point where the cone has passed, the color of the part is a steel gray, suggesting a temperature there between 950 deg. and 1000 deg. F. However, many experiments with torch annealing that have given hardnesses comparable to those obtained by other means of tempering indicate an actual temperature of 1200 deg. to 1325 deg. F.

There are several precautions that should always be remembered:

(1) Do not attempt to torch-anneal tool steels, as they will invariably crack.

(2) If annealing any of the higher-carbon S.A.E. steels, such as 2340, 3140, 4140, etc., a preheat of approximately 400 deg. to 450 deg. F. must be used. Even on these types of steel a man with a great deal of experience must proceed with caution in order not to crack the parts.

It is probably best to confine localized flame annealing to those steel parts that have been carburized.

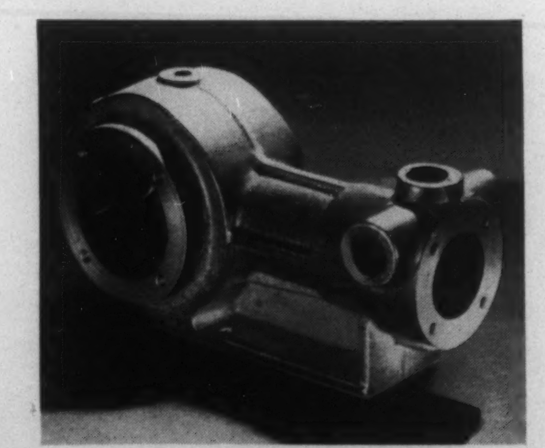
Spraying worn locomotive-parts with stainless steel by a metallizing process and re-machining to size is producing reconditioned parts giving from 100 to 300 per cent of their original service life on a Midwestern railroad. Prior to the spraying, all surfaces to be coated are sand-blasted. The coating depth is 1/64-1/32 in. in excess of finished size, which is obtained by machining to a high finish in a lathe, or by grinding.

—*Nickel Steel Topics*
International Nickel Co., Inc.

Salvaging Porous Castings

by Frank Less
Durez Plastics & Chemicals, Inc.

Very often "leakproof" castings expected to hold a certain pressure are made by good practice and are practically perfect, yet are found to be unable to hold the specified pressure under test. Such castings may usually be made entirely satisfactory by impregnating them with a phenolic resin specially formulated for that purpose, such as Durez 7347A.



In the case of the pump casting illustrated, for example, the specifications called for resistance to 500 lbs. water pressure, but inspection revealed sufficient porosity to cause leaking at 100 lbs. pressure. After impregnating with the special resin the casting was found to withstand 800 lbs. water pressure without leakage. The machining cost of $15.00, as well as the casting itself, was saved at the small cost of the impregnation.

The impregnation is accomplished by forcing the resin into the pores of the casting under air pressure. With small castings this may be done in a suitable pressure tank. Larger castings may be sealed and the resin pumped directly into the casting. Pressures between 45 and 100 lbs. per sq. in. should be used.

After the resin has been forced into the casting under pressure, the casting must be baked to "set" or polymerize the resin. Small castings may be baked in an oven for several hours at 250 deg. to 275 deg. F. or preferably in the pressure tank by applying steam at 20 lbs. pressure for 2 hrs., followed by 100 lbs. for 2 hrs. Baking under pressure will produce a cleaner, smoother surface. Large castings may be baked by applying steam direct at the same pressures.

Durez 7347A resin hardened in this way is practically impervious to water, solvents, mild alkalies and acids. The treatment has been approved by the Navy for use on certain types of pump castings.

"Early" Cupola-Firing for Hot Iron

by M. L. Carl
Sloss-Sheffield Steel & Iron Co.

Many foundries have worked out a satisfactory practice for assuring uniformly hot iron at the beginning of every heat, but many others are still having trouble in getting their first iron sufficiently hot. Although it is not offered as a "cure-all", we recommend in such cases the practice of starting the cupola-fire early—*four to six hours before the time for the blast to be turned on.*

Many of the larger melters are unconsciously securing the benefits gained by this procedure, because of the necessary time required to burn their coke-bed properly, plus the time required to charge the fill-up charges in the larger cupolas—all of which adds up to several hours. On the other hand, many foundries operating small cupolas, or operating cupolas for only one- or two-hour heats, have overlooked the advantages to be had by such a practice.

These advantages are numerous, particularly at present, when the cry is for greater production speed. In most cases, with no change other than the one mentioned, the melting rate of the cupola can be increased an appreciable amount, generally accompanied by a much-desired increase in temperature of the first-iron tapped. The increase in melting-speed may be enough, in some foundries, to allow the melting of larger tonnages in the same length of time formerly required for smaller heats, and thus permit more time for molding where molders pour their own work.

Faster melting during the earlier part of the heat may be expected, since the bed-coke has had time to be evenly ignited throughout, thus making the entire cupola area available for melting at the beginning of the heat. With sufficient time thus allowed for the coke near the lining to become well-ignited, the lining has enough time to be heated to a red-heat in the melting-area, which means that the melting-zone will reach its maximum temperature much quicker upon starting the heat than would be possible with a colder lining.

And, a hot lining naturally chills the first-iron and slag less than a cold lining, largely eliminating the tendency for the slag to stick to the lining and begin bridging, and being less inclined to continue when started. This explains partly why hotter and faster melting may be expected.

Other factors contributing to a hotter iron may be that the patching and daubing materials in the melting-zone have been heated slowly and long enough so that they are thoroughly dried, and possibly their surface fused. It stands to reason that patching-material that is dried slowly but thoroughly, and then raised to a red-heat before being subjected to the intense heat developed shortly after the blower is started, will result in far less bridging and less burning-away of the lining, both of which will mean a cleaner cupola, conducive to hot and fast melting.

A foundry interested in allowing the bedcoke to burn for a longer time may have to make some radical changes in the habits of the cupola-tender and helpers, for ordinarily, they arrange their work so that the cupola is repaired and ready to light the fire, just in time to allow the bed barely to burn through before charging is started. Many times, the blower must be started before the cupola is fully charged. This feature must be worked out in the individual foundry, but while the bed is being allowed to burn, the cupola-crew will have time to perform their other duties, which they may have been in the habit of doing earlier in the day.

There is only one precaution to be taken when allowing the bed to burn several hours, and this is not to allow the coke bed to burn completely away or unnecessarily. After the coke once starts burning, nearly all the draft may be cut off, depending upon the natural draft of the individual cupola.

About one-half of the bed coke is charged when the fire is started, and after this has burned through slowly, approximately another one-quarter of the bed is added, but the bed should be left so low that ten or twelve inches of coke will be required to bring the bed up to the desired level, just prior to charging the first iron.

Despite careful handling, abrasive often drops onto the floor around a blast cleaning machine, creating an unsightly and wasteful condition. One foundry corrected it by cutting a pit 6 in. deep by 12 in. wide the full length of their blast cleaning machines and covering the opening at floor level with an iron grating. When loose abrasive accumulates, it is swept into the pit, and after enough has been collected, it is shoveled back into the mill.

—*Wheelabrator Digest,*
American Foundry Equipment Co.

* * *

There's gold in them thar' earthy, practical ideas of yours. Metallurgical engineers can use them, and M. & A. will pay for all original "kinks" published in this department.—The Editors

Producing Flattened, Sealed Tubes

by L. Kasper
Steel Heddle Mfg. Co.

A number of steel tubes, of 1/16 in. wall thickness, were to be flattened on both ends and then sealed. It was found impossible to obtain non-porous seals by welding, probably due to the gases formed by the disintegration of the oil film on the inside of the tubes. However, brazing with a low-temperature alloy resulted in satisfactory sealing.

The tubes were first flattened as shown in section at the end A, in Fig. 1. The ends were then ground to form the arcs shown in the upper view of Fig. 1, after which a bead was built-up on the ends by torch-brazing with the brazing alloy, as shown at B, in Fig. 1. After the ends were polished and buffed, the tubes were nickel-plated, the seal not being discernible under the plating.

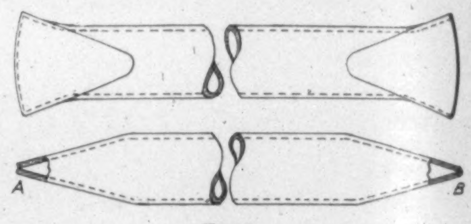


FIG. 1

This method proved entirely satisfactory until it became necessary to produce some parts of this type with a hard-chromium-plating instead of the nickel plate. In addition to the etching caused by the action of the chromic acid, the plated braze showed a different color from the plated steel, and seemed to have a different rate of plating, resulting in a pronounced and objectionable line of demarcation. After experimenting with a variety of brazing alloys without success, it was decided to employ a method that would expose a minimum amount of the brazing alloy to the action of the plating solution.

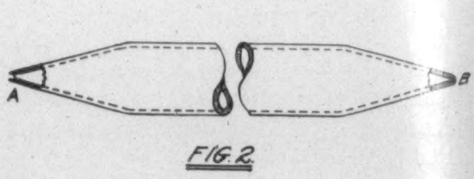


FIG. 2

After flattening and forming the ends of the tubes, a saw kerf was cut in the ends, as shown at A, in Fig. 2. The ends were then closed by hammering, so that the joint appeared as a line, as shown at B, in Fig. 2. After brazing and polishing off the excess brazing alloy, the seam could not be detected, and after plating appeared merely as a fine scratch, which was not objectionable.

Metallurgical Engineering Digest

FERROUS AND NON-FERROUS

A Digest of Important Developments in the World of Metals

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1a. Ferrous

Silvery Iron for the Cupola

"Increasing Silicon with Silvery Iron." Bradley H. Booth (Jackson Iron & Steel Co.) *Foundry*, Vol. 69, Mar. 1941, pp. 40-41, 110, 112. Practical.

Silvery pig iron is an important source of silicon for cupola charges containing low-silicon pig, much gray iron scrap and steel. The low-carbon content of silvery iron makes it suitable where the carbon content of the charge and iron produced must be held to a minimum. Silvery iron with high-manganese, phosphorus or other alloying elements provides an effective means for introducing such elements into the mixtures melted in the cupola.

Usually from 3 to 20% silvery iron is used in mixes having a high percentage of scrap steel. Typical mixes used at some foundries are as follows:

(1) For high strength, close grained iron of 40,000-50,000 lbs./in.^{2}—silvery pig (charge 16), 9.0% Si and 2.0% Mn; returned scrap (charge 34), 2.0% Si and 0.75% Mn; steel (charge 50), 0.20% Si and 0.65% Mn; carbon content held below 3.0%.

(2) For furnace castings with high carbon, resistance to growth and good fluidity—silvery pig (charge 10), 7.0% Si and 1.50% Mn; pig iron (charge 15), 2.0% Si and 1.5% Mn; returned scrap (charge 25), 2.30% Si and 0.75% Mn; purchased scrap (charge 50), 2.0% Si and 0.60% Mn.

(3) For castings requiring fair strength and machinability—silvery pig (charge 3), 7.0% Si and 1.25% Mn; stove plate scrap (charge 80), 2.20% Si and 0.50% Mn; steel (charge 17), 0.20% Si and 0.60% Mn. The strength of this iron may be as high as 32,000 lbs./in.^{2}

(4) For cupola malleable—silvery pig (charge 8), 8.0% Si and 1.50% Mn; returned scrap (charge 40), 1.0% Si and 0.40% Mn; steel (charge 52), 0.20% Si and 0.60% Mn. Duplexing is used for quicker, cheaper and more flexible malleable melting. The average cupola charge is silvery pig (charge 12), 10.0% Si and 2.0% Mn; returned and purchased scrap (charge 40), 1.20% Si and 0.40% Mn; steel (charge 48), 0.20% Si and 0.60% Mn.

In the steel foundry, silvery pig (15% grade) is used in the open hearth for hurrying the heat, controlling ferric oxide in the slag, blocking during finishing, and in the converter as a source of silicon for cupola mix. Silvery pig is added with the charge or to the bath of molten metal, depending upon the results desired. It helps to bring up the temperature quicker and aids in removing oxide from the bath.

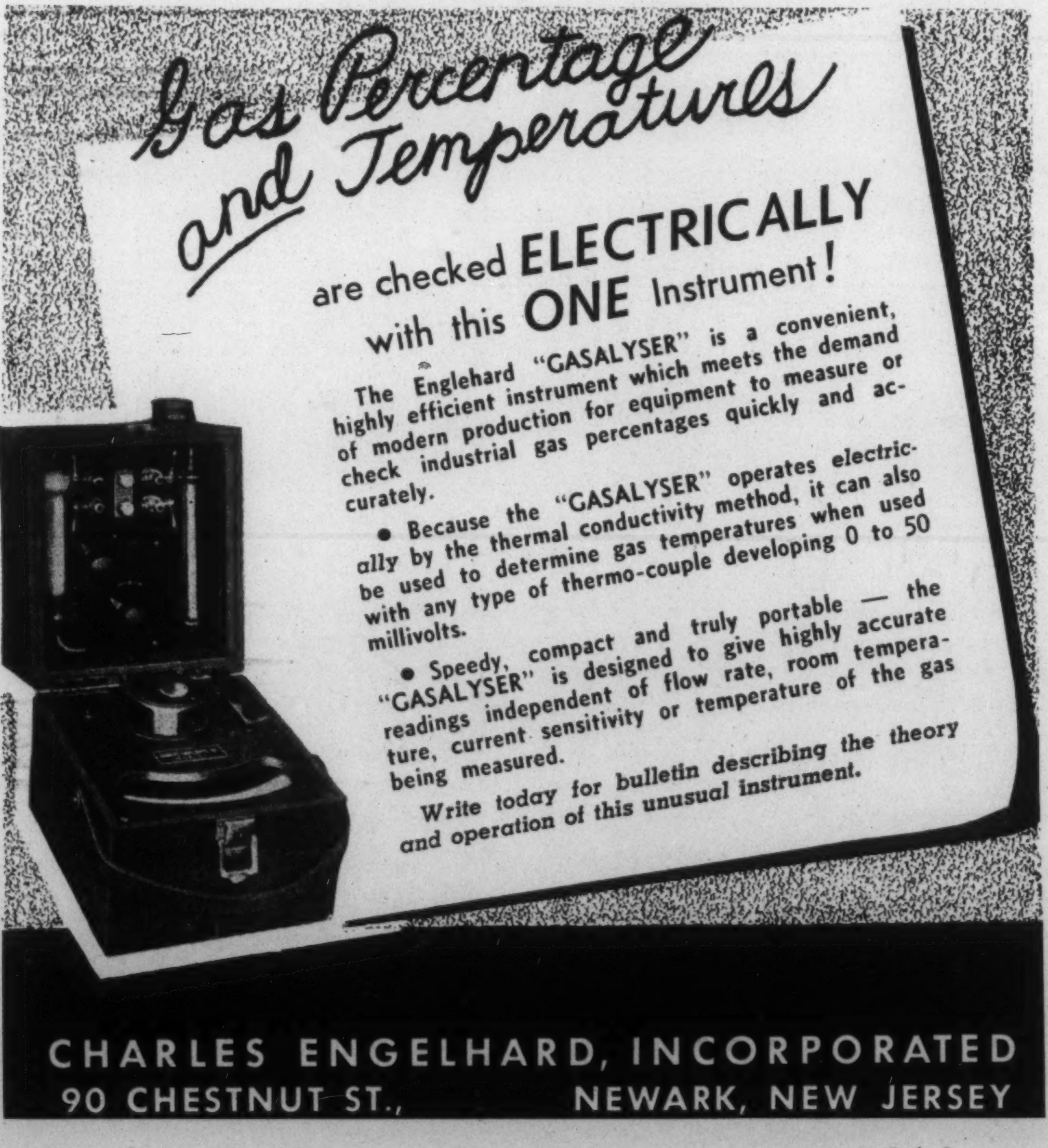
A study was conducted under normal foundry conditions using silvery iron of the 7 and 10% Si grades, to produce a cast iron of about 3.30% C, 2.00 Si, 0.65 Mn, 0.09 S and 0.30 P. Tests on 6 samples showed transverse strength (measured at half radius position) of 2421-2495 lbs., tensile strengths 33,400 to 34,525 lbs./in.^{2}, Brinell hardness (18 in. centers) 202-207, metal temperature at spout 2740° and 2750° F. and pouring temperatures 2490° to 2520° F. The iron produced was not intended to be a high test iron but rather a good ordinary gray iron made from mixes containing 90% scrap and no steel. VSP (1a)

Cooling of Steel Ingots

Primary Crystallization of Steel—Undercooling and Nuclei Formation in the Molten State ("Zur Frage der Primärkristallisation des Stahles: Unterkühlbarkeit und Keimbildung im flussigen Zustand") P. Bardenheuer & R. Bleckmann. *Stahl u. Eisen*, Vol. 61, Jan. 16, 1941, pp. 49-53. Research.

In small 1/3-lb. steel melts in a Tammann furnace (temperature measured by a platinum-rhodium thermocouple) it was possible to obtain decided undercooling—as much as 450° F. That is, the melt remains liquid even when the temperature fell as much as 450° F. below the freezing point; as freezing began, there was a rise in the time-temperature cooling curve.

Undercooling occurred only when the melt was held still and completely covered with slag. In low-carbon melts with < 0.01% C undercooling was about 450° F.; in 0.4% C melts the undercooling was about 360° F. This decreased in higher-carbon melts. Since stirring the melt or



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breaking the slag layer eliminated undercooling, it was concluded that no appreciable undercooling occurred when pouring large melts.

Practically no undercooling was obtained in 25-lb. induction furnace melts cooled in the furnace. Undercooling previously reported in large melts is attributed to erroneous temperature measurements with optical pyrometers.

The effect of nuclei formers on undercooling was studied. Additions of aluminum, beryllium, boron, calcium- aluminum, calcium-aluminum-silicon, titanium, vanadium and zirconium were found to eliminate undercooling. Additions of manganese, silicon, calcium-silicon, chromium, cobalt, molybdenum, nickel, phosphorus, sulphur, tungsten and nitrogen were found not to hinder undercooling. The effects of hydrogen and oxygen were intermediate between these two groups of additions. SE (1a)

Freezing Points of "Impure" Steels

"Freezing Temperatures of High-Purity Iron and of Some Steels," Wm. F. Roeser & H. T. Wensel. *J. Res. Natl. Bur. Standards,* Vol. 26, Apr. 1941, pp. 273-287. Research.

The freezing temperature of high-purity iron (99.99+%) in an atmosphere of helium was measured with an optical pyrometer and found to be 1,539° ±1° C. The same samples of iron were found to freeze 1° C. lower in an atmosphere of hydrogen. In addition, the initial freezing temperatures in an atmosphere of helium of some irons of lesser purity and of some steels were measured to determine the effects of various impurities and alloying elements.

How Impurities Lower the Freezing Point of Iron

Element	Depression of freezing point per per cent by weight, in °C.	Range of element in materials investigated (per cent by weight)
Hydrogen	1,300 (computed)	0 to ?
Nitrogen	90 (computed)	0 to 0.03
Oxygen	80 (computed)	0 to 0.03
Carbon	65 at 0%C 70 at 1%C 75 at 2%C 80 at 2.5%C 85 at 3%C 91 at 3.5%C 100 at 4%C	0 to 3.8
Phosphorus	30	0 to 0.7
Sulphur	25	0 to 0.08
Arsenic	14	0 to 0.5
Tin	10	0 to 0.03
Silicon	8	0 to 3
Manganese	5	0 to 1.5
Copper	5	0 to 0.3
Nickel	4	0 to 9
Molybdenum	2	0 to 0.3
Vanadium	2	0 to 1
Chromium	1.5	0 to 18
Aluminum	0	0 to 1
Tungsten	1	18% W with 0.66% C

The results of measurements on 23 samples of irons and steels, together with the chemical analyses, are reported. The freezing-point depressions of the various elements are listed in the table, which may be used to calculate the initial freezing temperatures (liquidus points) of iron containing many combinations of 17 elements, which include all those generally found in commercial irons and steels.

The samples containing less than 0.1% impurities were melted in beryllium oxide crucibles and the other samples, in all but two cases, were melted in crucibles of aluminum oxide. Temperatures were determined by means of an optical pyrometer sighted into refractory blackbodies immersed in the freezing metal. The freezing temperature of Armco ingot iron in helium is 1,534°±2° C. The depression of the

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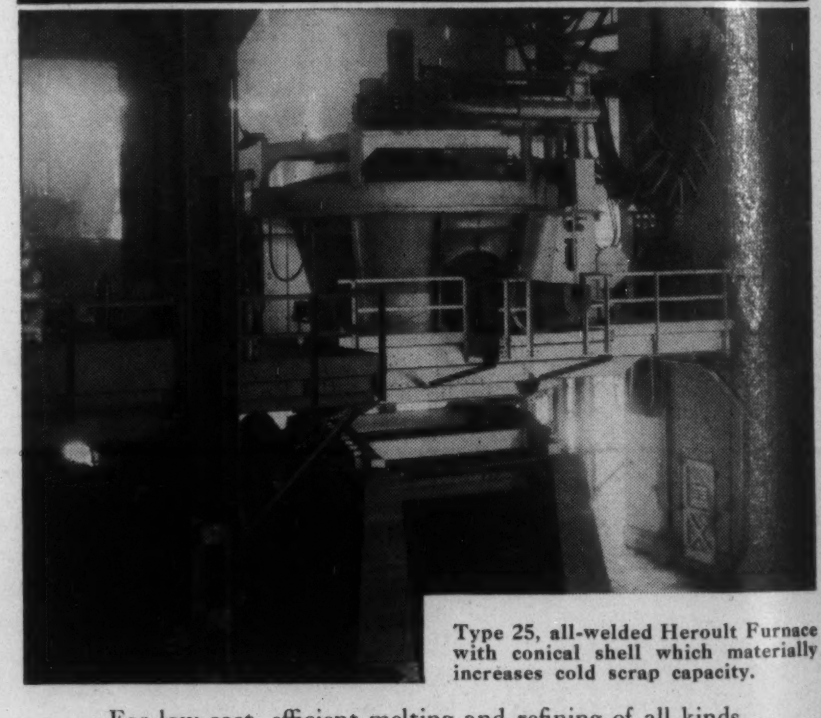

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initial freezing temperature of an iron or steel by most of the elements commonly found in steels is independent of the presence of other elements. *Thus the initial freezing temperature of a steel can be calculated from the chemical composition.*

WAT (1a)

Hydrogen in Steel and Slag

HYDROGEN EQUILIBRIA IN STEEL MAKING ("Wasserstoff gleichgewichte bei der Stahlerzeugung") P. HERASYMENKO & P. DOMBROWSKI. *Arch. Eisenhüttenw.*, Vol. 14, Sept. 1940, pp. 109-115. Original research.

A new sampling device for determining the hydrogen content of molten steel is described. In this the steel is poured into a cylindrical mold which is capped and the gases evolved during solidification are analyzed. The changes in hydrogen content during the course of open hearth heats were determined.

Boiling of the heat had very little effect on the hydrogen content. On the other hand, the hydrogen content curve followed the manganese content curve very closely. As the manganese decreased the hydrogen decreased. When the the manganese increased, because of manganese reduction from the slag, the hydrogen also increased. After additions of spiegel or ferromanganese to the bath there was a sharp rise in the hydrogen content.

Analyses indicated this could not be due to hydrogen carried by the ferro-alloy additions. Instead it was attributed to hydrogen reduction from the slag, according to the following equation: $H_2O + Mn = H_2 + MnO$. This reduction varied with temperature in the same way as manganese reduction from the slag; the higher the temperature the more hydrogen reduction.

A similar sampling device was used to determine the hydrogen content of the slag above the steel bath. The hydrogen content of the slag was about 3 times that of the steel bath. During pouring of steel from large ladles of commercial open-hearth and electric arc-furnace steel very little change in the hydrogen content occurred.

In ingots, segregation of hydrogen to the upper central portion took place. In forgings cooling in lime gave lower hydrogen contents than cooling in air. After air-cooling an hydrogen content of over 4.5 $cm.^3$/100 g. resulted in flakes.

SE (1a)

Making Stainless-Clad Steel

"ARMORED STEEL." T. W. LIPPERT (Staff) *Iron Age*, Vol. 147, Mar. 6, 1941, pp. 35-45. Descriptive, with history and patent review.

The latest development among composite (stainless-clad) steels is the "Pluramelt" process, worked out by R. K. Hopkins and now commercially employed by Allegheny Ludlum Steel Corp. The carbon steel base used is in the form of a slab (or ingot), which may have been sandblasted (or surface preparation may be ignored). The alloy "armor" is produced from powdered ferro-chromium, powdered ferro-silicon, powdered ferro-manganese, powdered ferro-columbium, etc., each of which is contained in a special hopper.

There is practically no limit to the complexity of alloy systems that can be automatically "metered" into the system at one time, although considerable metallurgical skill is necessary for close analysis control. A frame is fastened around the slab, lowered into the Pluramelt machine, and fixed so that about a 2 in. space is left between the slab surface and the mold wall. In this space a working head, (carried by the frame work that runs vertically) is lowered. The feeding mechanism for raw materials is located in various sections of superstructure.

The practice involves a continuous and precise feeding of the constituents through the working head. The feeding equipment includes metering machines, controlled from a central operating panel, with each meter connected with a hopper containing a particular raw material.

No iron powder is fed into the working head. The iron constituent for the alloy is made up in part from iron carried into the system by the ferro-alloys, and in part from iron picked up from the melted portion of the exposed face of the carbon steel. The necessary slag constituents are fed by hand as required into the space between the slab and the mold wall. The electrical energy required varies with the alloy made, the size of the slab, and the speed of operation.

The operation is thus a complex mechanical system with very little personal supervision needed. The working head moves from the bottom of the slab upward, with alloying material constantly feeding to the bath underneath the slag. The pace of the upward movement of the working head is gradually changed to offset the rising temperature of the slab face and the mold space. All material is constantly checked during the operation.

Pluramelt composites can be stitched or seam- or arc-welded with no deterioration

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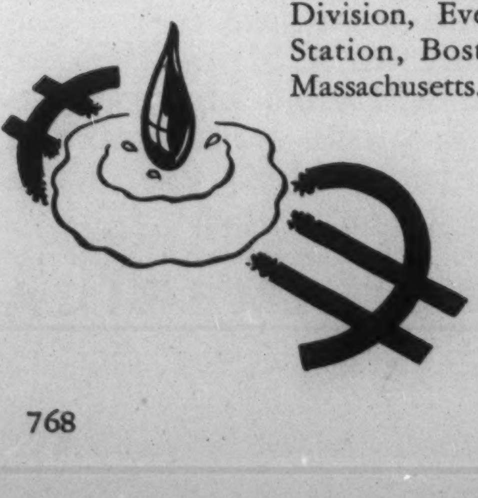

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of the joint. Full penetration is achieved with one bead and a bead laid from the alloy side. Higher-alloy rod is used than the analysis of the alloy cladding.

Pluramelt sheets, particularly "double-armored" material (clad on both sides), can be subjected to much more severe cold working without annealing than solid stainless or alloy material of comparable gage. The stainless layer is very uniform after drawing and polishing.

Tests show that this process is an efficient primary steel producer; the alloys are controllable to within narrow limits and are high and uniform, and ingot piping and crop losses are almost negligible. The set-up of the melting and feeding units can be operated in a water-cooled copper or refractory mold, which may be of any shape. High yield and the fact that the product is so close to the finished article make the final cost quite reasonable.

VSP (1a)

High-Strength Cast Iron

A Composite

That the days of gray cast iron are far from numbered is strikingly indicated in the tremendous current demand for iron castings in military equipment and in machinery and machine tools for defense production. Cast iron's strong competitive position is due not only to certain inherently desirable properties, but to the development in recent years of several types of high-strength iron, both plain and alloyed.

Alloy Irons

High-strength irons must generally be made in the cupola, points out A. E. McRae-Smith ("Melting and Casting Problems in the Production of High-Strength and Special-Duty Alloy Iron Castings," *Foundry Trade J.*, Vol. 64, Mar. 20, 1941, pp. 191-193; Mar. 27, 1941, pp. 203-204, 212), although electric, rotary and other "special" furnaces are used in several favored foundries.

Special-process cast irons within the range 2.6-2.9% T.C., either alloyed or unalloyed, cover the largest field of high-strength castings. Among the alloy irons, nickel alloy iron ("Ni-Tensyl") is extensively used where tensile strengths of 50,000-55,000 lbs./in.^{2} are required with higher shock-resistance than ordinary engineering irons. Standard compositions may be modified to meet special requirements, *e.g.* for highly-stressed gears, nickel-molybdenum irons are suitable.

An interesting recent development has been the production and application of nickel, molybdenum and nickel-chromium-molybdenum cast irons with acicular or pseudo-martensitic structures. Molybdenum is neither a graphitizer nor a strong carbide former, but by reason of its matrix-improving qualities, it greatly increases the tensile strength of any grade of cast iron.

Combinations of nickel and molybdenum produce the maximum beneficial effect on the physical properties of gray iron. Acicular structures are a function of molybdenum as an alloy constituent. If a dendritic graphite pattern is produced, no matter what the matrix structure is, the physical properties will decline very steeply.

In all types of high-strength irons, whether made by special processing or by alloy combinations, or both, it is essential to have random pattern graphite. In most cases this is ensured by late silicon additions or other forms of graphitizing additions.

Tensile strength tests show that a phosphor content of 0.4% is the most that can be tolerated in nickel-molybdenum cast iron. The sharp drop in impact value on passing from 0.1 to 0.2% P in nickel-molybdenum iron is probably due to the substitution of a pearlitic for the acicular structure.

Hot-Blast Cupola

Melting practice was studied by K. Ishikawa ("The Melting of Cast Irons at High Temperature, and the Hot-Blast Cupola," (In Japanese), *Nippon Kinzoku Gakkaisi,* Vol. 4, Dec. 1940, pp. 418-448) with particular attention to the production of cast iron of high abrasion resistance and strength. In melting the pig iron, the graphite is refined by a melting temperature of 2700° F. and above, and also by casting temperatures ranging from 2465° F. to 2550° F.

The high temperatures in this work were obtained with a hot-blast system. The advantages of the hot-blast cupola are (1) the temperature of the molten metal is about 145° F. higher than that in an ordinary cupola, and (2) from the first tapping, the temperature of the molten metal is high, and the fluctuation of the temperature throughout the operation is very little.

Also, (3) air of high humidity can be blown in, (4) 20-30% of the coke consumption can be saved, (5) casting rejects can be reduced, and (6) second grade coke may be used.

Heat Treatment

A combination of alloying (with molyb-

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denum) and heat treatment was studied by I. FERRARO ("Influenza del trattamento termico sul comportmento all'usura delle ghise grigie per canne cilindri," *Ind. Meccanica*, Vol. 22, Sept. 1940, pp. 452-458) for the production of gray iron of high wear-resistance. Two irons were used—an unalloyed iron with 3.26% T.C., 2.01 Si, 0.70 Mn and 0.52 P, and a molybdenum iron with 3.09% T.C, 1.65 Si, 1.03 Mn, 0.47 P and 0.53 Mo.

Small test blocks of the irons were prepared and tested (a) as-cast, (b) quenched from 1500° F., (c) and quenched from 1560° F. and drawn at (d) 1100° F., (e) 1025° F., (f) 925° F., and (g) 840° F. The tests consisted of measuring the impression made on the face of each test block when held against a rotating cast iron disk, the peripheral speed of rotation being about 25 ft./sec. and the pressure about 3,000 lbs./in.^{2}

The results indicated that in both the as-cast and as-quenched state the molybdenum iron was significantly more wear-resistant than the unalloyed material. In both types of iron tempering at or above 925° F. results in lower wear-resistance than in the as-quenched state, the drop being more marked in the case of the unalloyed iron than in the alloyed iron.

For practical purposes, the molybdenum iron is recommended only when its higher wear-resistance after tempering at 840° F. (nearly double that of ordinary iron) justifies the extra expense. X (1a)

1b. Non-Ferrous

Aluminum Aircraft Castings

"ALUMINUM CASTINGS FOR AIRCRAFT." NORMAN E. WOLDMAN (Bendix Aviation Corp.) *Iron Age*, Vol. 147, Feb. 27, 1941, pp. 37-43; Mar. 6, 1941, pp. 49-52. Practical discussion of sand castings.

Aluminum casting alloys may be classed as (a) sand castings for large or intricate cored castings; (b) permanent mold castings, used where a large number of parts of the same pattern are required; (c) die castings, adapted to quantity production of small castings in which close dimensional tolerances are required and the cost must be held to a minimum; (d) plaster mold castings, which are similar to sand castings but with smoother surface.

A very popular aluminum casting alloy is the aluminum-silicon type. These are very fluid, have good casting characteristics and are thus used for thin-walled and complicated castings that must be dense and leak proof. They have very low specific gravity and good corrosion resistance, but their machining properties are inferior. The aluminum-silicon alloys have lower yield strength than copper-aluminum alloys, but greater impact resistance and ductility.

The aluminum-copper alloys respond to heat treatment and therefore are stronger and harder. They are not pressure-tight but have good casting qualities and machinability. The aluminum-copper-silicon alloys are particularly suitable for permanent mold and die castings. They are not as resistant to impact as aluminum-copper alloys, and less corrosion resistant than the aluminum-silicon alloys. They are leak-proof, pressure-tight and retain their strength up to 400° F.

Aluminum-magnesium alloys are difficult to cast, but have maximum corrosion resistance. They have good mechanical properties and machinability. Aluminum-magnesium-copper alloys have good heat treating qualities. The aluminum-magnesium-nickel alloys have good properties at elevated temperatures and are not subject to permanent growth on heating; their

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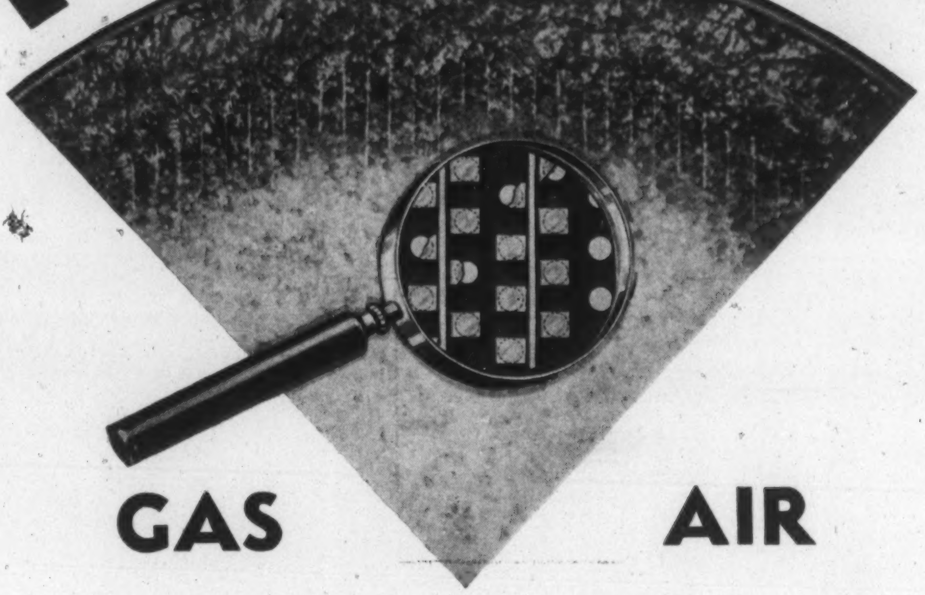

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What chance has a particle of ash, dust or fume to escape in the gas stream on its travel through cleaning stages like these? The answer is NONE, unless it is so tiny that it can hide behind the decimal point on a micron scale.

Should it escape capture in passing the first stage, it will only enter a second or a third, if necessary, depending upon the degree of cleanliness desired for the gas. At each stage, plate openings will be smaller and gas velocity through them against the impingement baffles higher, assuring ultimate entrainment of the unwanted particles, to be flushed away in the scrubbing water.

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strength is retained up to 600° F. They can be heat-treated and become very hard after aging following the solution treatment.

Sand casting is the most common method of casting aluminum alloys. They have low strength at temperatures just after solidifying if free contraction of the metal is not allowed. The low specific gravity of the alloys makes extra venting necessary, so that all gases can be removed from the mold rapidly; either dry or green sand cores are used. The shrinkage allowance for patterns is 5/32 in./ft. Sand-cast aluminum alloys are used in aircraft for carburetors, hot air scoops, fuel line fittings, fuel and oil tank flanges, pistons, gear cases, oil pans, pedals, etc.

Permanent mold castings have the advantage over sand castings in greater strength and ductility, more exact size, and better surface. Alloys used for permanent mold casting have greater resistance to corrosion and greater susceptibility to heat treatment due to their fine grain and the greater density of the metal. Permanent molds should be of close-grained low-phosphorus gray iron. For complicated cores dry sand can be used.

The mold should be heated to about 750° F. to avoid cracks. Gravity feed is used in filling the mold. Although the mold is hot, molten metal is chilled rapidly and the casting is dumped out while still at a high temperature. Molds are poured so that the part of the casting farthest from the gate solidifies first. Castings, depending on their size and design, can be cast with 3/32 in. minimum wall thickness. Usually 1/32 in. is allowed for machining.

Plaster mold castings are obtained from a mold made of a mixture of gypsum, water and a binder such as asbestos. The molds are hardened, removed from the flask and baked at 1400°-1500° F.; this treatment leaves them porous to allow gases to escape. Castings can be held to tolerances of ±0.005 in. or better. Many aluminum alloys can be cast by this method.

VSP (1b)

Fluxing Aluminum Melts

"Progress in Research and Control." *Light Metals*, Vol. 3, Apr. 1941, pp. 77-79. Review.

The idea is sometimes advanced that in melting aluminum or aluminum alloys for castings, no flux is needed on the surface of the melt—that the film of aluminum oxide formed over the top prevents further oxidation. While this viewpoint may be justified for an ideal case, actually it is better to use fluxes to aid in producing clean castings.

Each lump of aluminum in the crucible forms its film of oxide, and if no flux is used, much of this oxide is entrained in the melt. Further, stirring or otherwise agitating the melt to aid alloying action introduces more oxide into the aluminum. There is no tendency for the oxide to rise to the surface, as the oxide is heavier than molten aluminum. Any movements of inclusions, particularly Al_2O_3, in the melt because of gravity or surface tension forces is much too slow for practical utilization, even if it could be demonstrated that an eventual separation is possible.

Flux Requirements

The prime requisite of a satisfactory flux for melting aluminum is the removal of such inclusions. It has been generally considered that to be effective, a flux must be capable of dissolving aluminum oxide. For this reason, cryolite and other halogen compounds of the alkali metals, especially the chlorides and fluorides of sodium and potassium, have been used. Calcium fluoride has been used to some extent for very impure or badly contaminated melts. Sodium chloride in flux mixtures is chiefly used as a diluent and carrier for the fluorides.

It is generally assumed that recommended fluxes have a high solvent power for aluminum oxide, but many of these claims are unsubstantiated. More likely, many of these fluxes have a more pronounced effect upon aluminum than on its oxide, as aluminum is the more reactive material of the two.

That some reaction with the metal does occur is evidenced by the fact that aluminum-silicon alloys can be "modified" by certain fluxes—especially by sodium fluoride, with the introduction of some metallic sodium into the melt. It is highly probable in such cases that the sodium thus introduced may react with the entrained aluminum oxide, reducing it to aluminum and sodium oxide (Na_2O). In fact, this latter reaction may occur rather than actual solution of alumina by the flux. Some experiments have been performed in which metallic sodium was added to aluminum melts followed by blowing with chlorine, with results that suggested the above hypothesis.

The mechanism of the cleansing action by satisfactory fluxes may lie in their ability to wet the particles of alumina and other inclusions when the flux is stirred into the melt. The flux particles naturally rise rapidly to the top of the heat and many bring inclusions along with them. This action appears to be more likely than actual solution, which would be expected to require considerable time, especially if only a small

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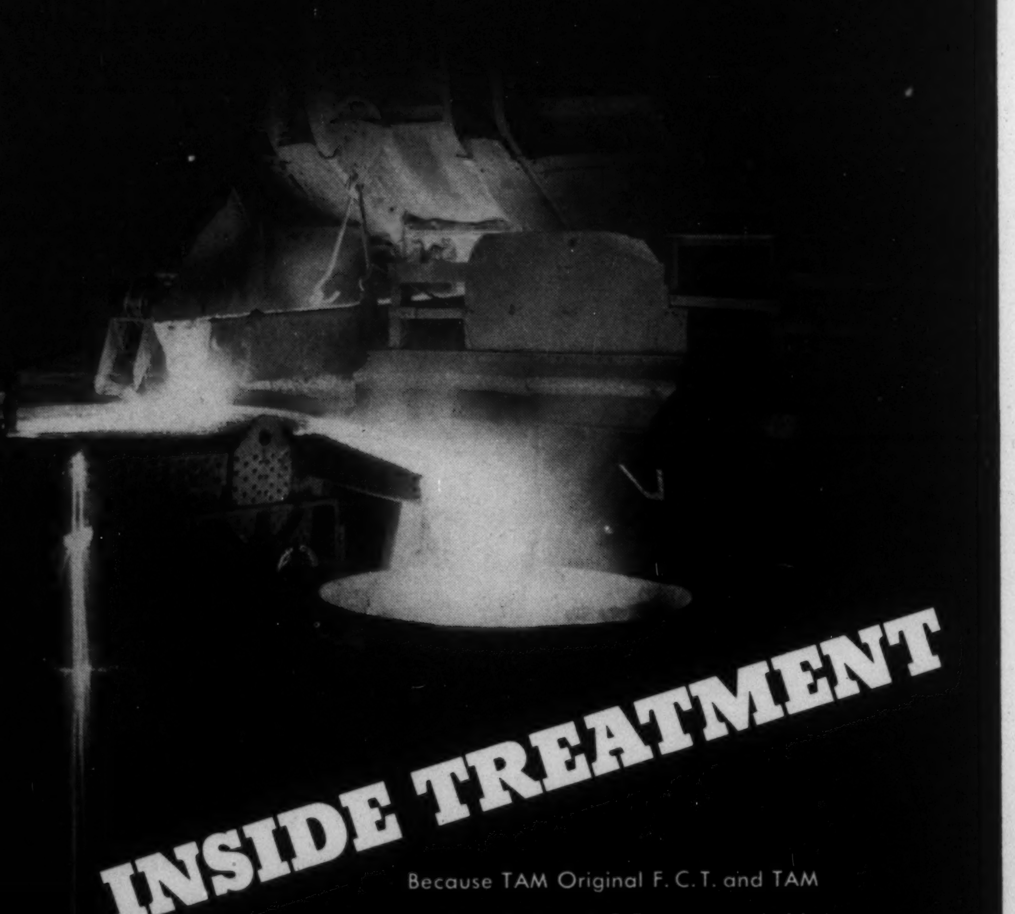

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amount of flux compared to the amount of metal is used.

Aluminum oxide inclusions, considering their mode of origin, would be expected to be of the film type rather than coalesced or spherical. Even assuming that fluxes are capable of some solution of alumina, the first action must be a wetting one, and this wetting of the alumina would tend to cause coalescence and hence facilitate removal, since in the coagulated form floating could occur more readily. Other inclusions such as aluminum nitride, carbide, silica, etc. would be expected to be wet in some degree and hence also floated.

Protection Against Gases

The use of liquid fluxes such as those described should not produce appreciable degassing. Another function of fluxes in light metal melting is to offer protection from the furnace atmosphere. In the case of magnesium alloys, a novel type of protective flux is dry ice. Contrary to what might be anticipated, there is no violent action; the melt and the dry ice are separated by a film of gaseous carbon dioxide, which offers very efficient protection from oxidation. During casting, the carbon dioxide flows along with the metal, still affording protection.

Chlorine is widely used and is very effective as a degasifier for aluminum melts. It is important to introduce the chlorine as far down into the metal as possible and to subdivide the stream of gas so that as much of the melt as possible is "washed." Sufficient time must be allowed for thorough treatment.

The chlorine treatment is especially effective as a hydrogen remover, hydrogen being the gas present in largest quantity in aluminum melts. The hydrogen and chlorine probably react to form hydrochloric acid. Some aluminum chloride is undoubtedly formed during the treatment.

Certain volatile salts such as aluminum chloride have been proposed as additions to aluminum heats for degassing, but except in the case of aluminum chloride itself, such salts must leave some metal behind in the melt if they decompose when added to the melt (and many do, *e.g.* zinc chloride). Also, reactive fluxes will tend to react with the most active element in the melt. This is usually aluminum, and such action is negligible, but in the case of active alloying additions such as magnesium, it is possible that the amount of magnesium or other reactive element may be seriously reduced in amount by the action of the flux.

AUS (1b)

Bronze Permanent-Mold Castings

"PERMANENT MOULDS AND THEIR APPLICATION TO THE PRODUCTION OF NON-FERROUS CASTINGS." FRANK HUDSON. *Foundry Trade J.*, Vol. 64, Mar. 1941, pp. 153-155, 158. Practical review.

Not only light metals, but copper alloy castings of high strength are being produced in permanent molds; results have been very satisfactory, for example, with aluminum bronzes. It has been long-standing practice, of course, to cast phosphor bronze in stationary permanent molds, giving chill-cast solid and cored sticks so widely used for bearings, valve guides, etc., and also in centrifugal molds for liners and gear blanks. Surprisingly little work has been done in England on the production of castings in refractory or refractory lined molds or on the permanent-mold casting of the more common copper alloys.

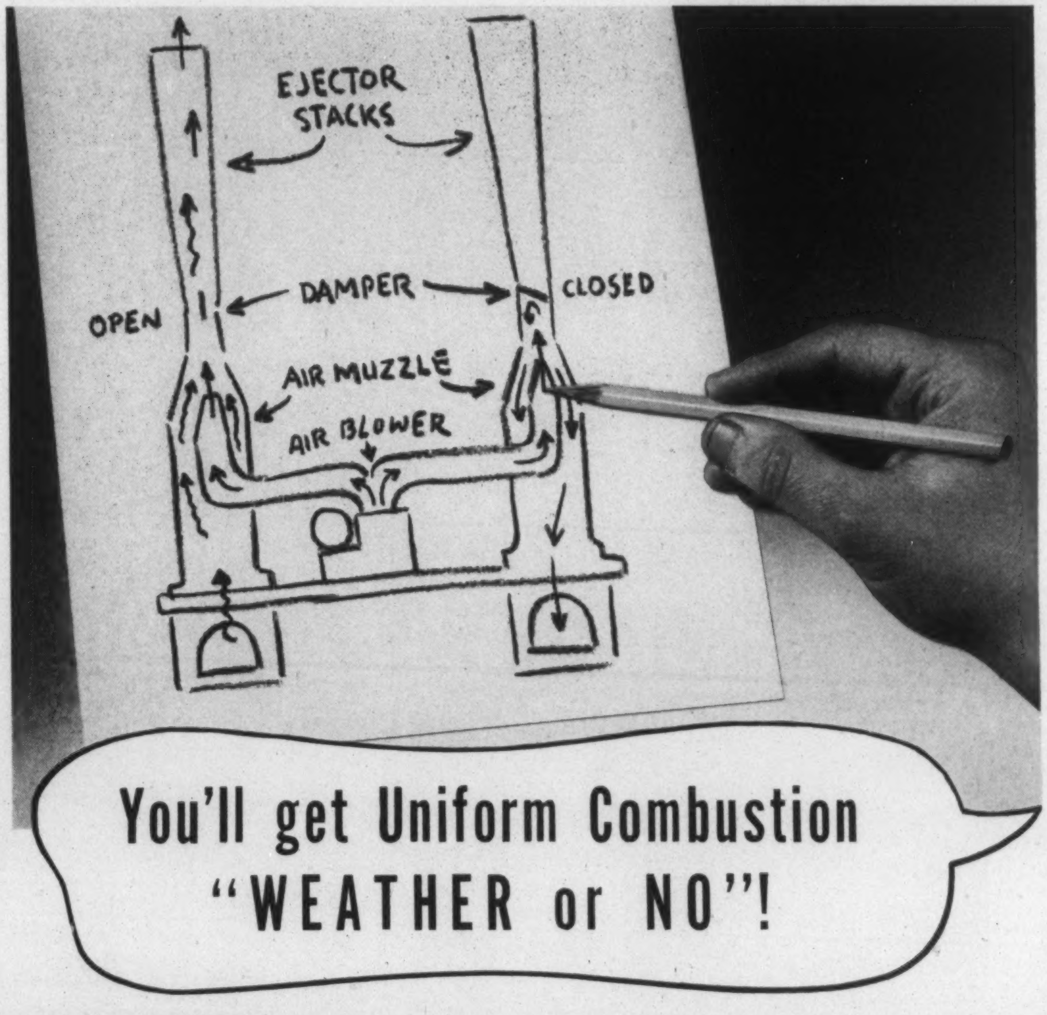
At the present time British demand for rolled phosphor bronze bars up to 2 in. diam. calling for a maximum strength of 65,000-85,000 lbs./in.^{2}, with not less than 15% elongation, exceeds the sources of supply, and it is necessary to find a substitute of similar type and properties. A likely material is a recently-developed age-hardening cast bronze containing 88% Cu, 5 Ni, 5 Sn and 2 Zn. A scheme was devised utilizing cast iron permanent molds, as an economical foundry method for the manufacture of 28 in. bars varying from ⅝ in. to 3 in. in diam.

Preliminary trials, however, proved disappointing, as bars cast in this way suffered from slight center porosity practically along their entire length. The cause of this porosity seemed to be the rapid cooling effect of the mold, which, in conjunction with lack of fluidity in the metal, prevented the necessary degree of feeding from taking place. Satisfactory results were obtained only after the adoption of centrifugal casting methods.

Owing to the relatively high temperatures involved, the casting of copper-base alloys ultimately causes failure of cast iron permanent molds through surface cracking or crazing. For general purposes, a low-phosphorus cast iron is usually employed. For very massive castings, it is desirable to use a hematite-type of base iron, high in total carbon. In the latter type, freedom from premature cracking and crazing may be obtained by adding 1.5-1.7% Ni with 0.4-0.6 Cr.

For special work, *i.e.* molds for centrifugal casting machines requiring high strength combined with good thermal shock and heat resistance, the use of the following composition is preferred: 2.8-3.0% total C, 1.6-2.0 Si, 0.8-1.2 Mn, 0.20 max. P, 0.12 max. S, 2.5-3.0 Ni, 0.5-0.7 Cr and 0.6-0.8 Mo.

AIK (1b)



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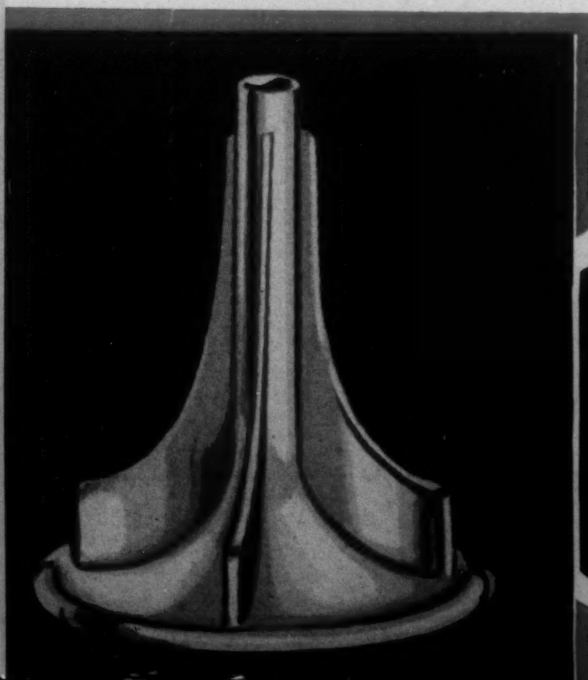

Steel for washing machine agitators.

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2

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Hot Tinning

"Hot-Tinning of Steel." *Can. Metals & Met. Inds.*, Vol. 4, Mar. 1941, pp. 50-53. Practical.

The hot-tinning process may readily be applied to mild steel, carbon steels, copper and many copper alloys, as well as to cast iron, provided that the basic metal is given special preparation. Some alloy steels and copper alloys are not suitable for hot-tinning operations. Hot-tinned coatings average 0.0005-.0010 in. in thickness; where thicker coatings are required, electro-tinning must be employed.

The features of hot-tinning are: bright lustrous coatings without blemish that do not tarnish readily in the atmosphere; adequacy of a simple plant; absence of need for laboratory control of the process; and rapidity of the tinning operation. Tin-lead alloy coatings may be easily applied. The hot-dipping process can be used to effect tinning and soldering simultaneously. Fabricated parts containing soft-soldered joints are unaffected by the temperatures employed.

Preparation of Sheet

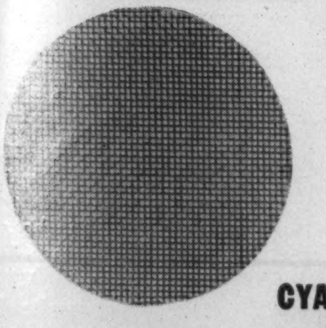
Preparation of sheet metal for hot-tinning requires degreasing and pickling. Degreasing may be accomplished by the use of organic solvents, alkaline solutions, or by heat. In the heat method the burning-off process may also be combined with the annealing required after drawing or pressing, and is very effective—provided the correct temperature is reached. The temperature required depends upon the metal and the nature of the oil or grease that must be removed. But it is necessary to employ a much higher temperature (1100° F. or over) than is required to remove obvious greasiness from the surface.

If de-wetting of the tin coating cannot be overcome by any of the degreasing methods it is necessary to resort to special pickling treatment. The shorter the pickling time, the smoother is the resulting finish. Nitric acid (25% by volume) is usually effective in overcoming the non-wetting of tin coatings.

Tinning

Tinning is best carried out with 2 pots—

HEAT TREATING BASKETS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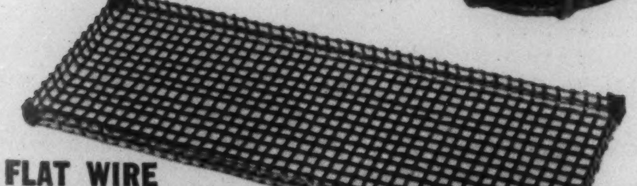
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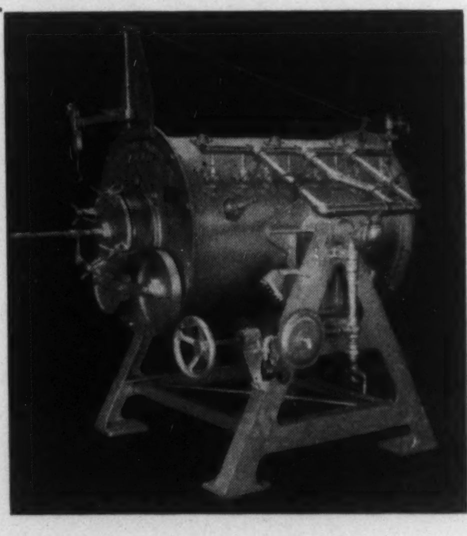

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the first covered with a layer of molten flux and the second with tallow or palm oil. A good deal of practice in handling the articles is necessary in order to obtain the cleanest results. Coverings of flux and tallow on baths do not remain in good working condition indefinitely and must be replaced.

The rapidity with which the molten tin coating solidifies affects the brightness of the finish, and the method of cooling adopted must be chosen with regard to the importance attached to brightness of finish, and to the thickness of steel of which the articles are made. In general, the purer the tin, the brighter the coating. Small percentages of lead and copper tend to produce a spangled effect, while antimony and bismuth have no appreciable effect on the appearance, in the quantities present in commercial tin.

Grease-Tinning Process

A typical "grease-tinning" plant for thin-gage steel consists of 5 pots: (1) the grease pot, (2) the rough-tinning pot, (3) the finishing tin pot, (4) a grease pot for drawing off the surplus tin and (5) a "listing" tin pot for removing drips. The articles are dipped into the usual zinc chloride flux and immersed in the tin pot through the layer of grease. In the process as now employed the first grease pot is used merely as an unheated storage pot for the grease, which is ladled from it to the top of the rough tin pot to a depth of some inches.

The articles are dipped into the usual zinc chloride flux and immersed in the tin pot through the layer of grease. Sufficient articles are immersed to fill the pot, a rack being provided upon which to stand them, and the grease is then ladled back into the grease pot. From the rough tinning pot, the article is lightly brushed over with a soft brush dipped in melted grease to remove dross and placed in the second tin pot, which is covered with a thin layer of grease and maintained at 480°-500°F.

An advantage of this process for thin sheet is the use of the grease draining pot for removal of surplus tin. Beef or mutton tallow, or a mixture of one of these with palm oil, is employed, although a recent development is the use of special mineral oils. Removal of iron contaminations is effected by the immersion of raw potatoes or pieces of green wood in the bath and maintaining the bath at 465°-480°F. An alternative method is to blow compressed air through the bath.

Other hot-tinning operations, including the tinning of steel in tin-lead alloy baths, and the tinning of alloy steels, cast iron and copper alloys, follow along the same general lines as the methods described.

WHB (2)

2a. Ferrous

Salt Baths

"Heat Treatment With Salt Baths." Lloyd E. Raymond. *Iron Age,* Vol. 147, Apr. 3, 1941, pp. 31-34; Apr. 10, 1941, pp. 52-56; Apr. 17, 1941, pp. 32-34. Correlated data acquired from published and unpublished sources.

The amount of sodium cyanide present in the bath influences the chemical composition of the case, the depth of penetration and the hardness of the case. Study showed that the lower *cyanate* content baths do not carburize with the effectiveness of the higher cyanate baths. The depth of penetration as observed under the microscope seems practically the same, but analysis of the case shows less total hardening units of carbon and nitrogen.

With increase of temperature in the cyanide bath greater penetration is obtained; at lower temperatures, carbon diffusion is slow and will produce cases that are hypereutectoid at extreme outer surfaces. As carburizing time is increased at any given temperature with a given bath, the depth of penetration will also be increased.

The grain size of steels influences the rate of carburizing, the coarser grain being the faster carburizing. To control the depth of case a preliminary normalizing is recommended.

Heavily-banded steels carburize in a somewhat spotty manner when treated at the lower temperatures, due to the tendency of the heavy ferrite bands to stop off carburizing; the result is shallow cases where heavy bands are parallel to the surface of the metal, and soft spots where the bands are perpendicular. When treated at temperatures where ferrite has transformed to austenite, no difficulty will be encountered from bands.

Types of Baths

The recently-developed "activated" baths aid in procuring a case on low-carbon steel that is much lower in nitrogen concentration. The baths contain barium or calcium compounds in addition to sodium cyanide, and can usually be operated at temperatures higher than ordinary cyanide baths, with consequently greater production. Such baths are operated with a flake graphite covering.

Cyanide baths may be made up by using a 45% sodium cyanide, 55% sodium chloride mixture. The operating addition may be 96% or 75% cyanide. The best practice is to add 1-2% of the weight of bath every hour during the operating day. If the cyanide content tends to drop, it can

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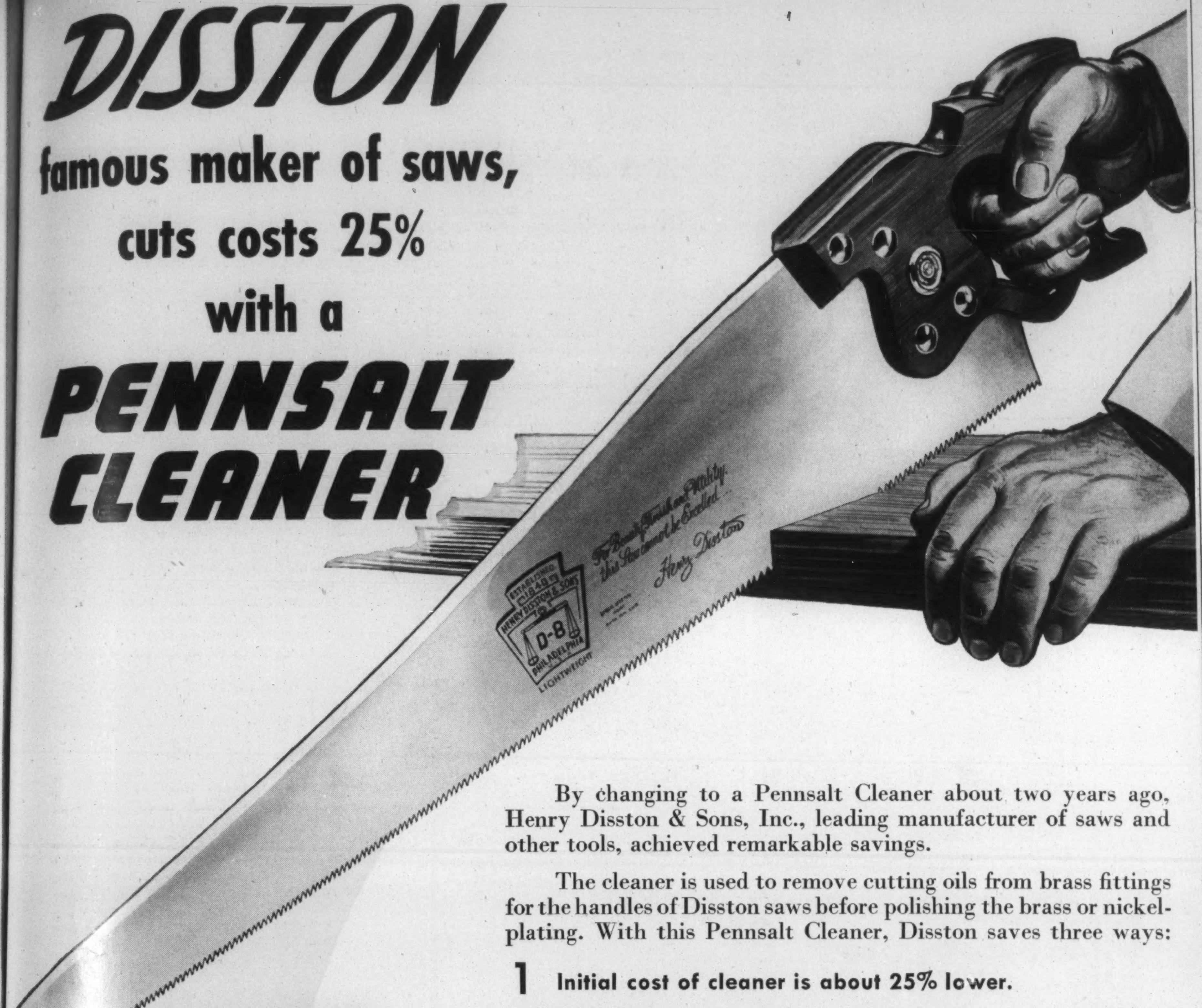

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The cleaner is used to remove cutting oils from brass fittings for the handles of Disston saws before polishing the brass or nickel-plating. With this Pennsalt Cleaner, Disston saves three ways:

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Chemicals

be restored by holding the bath at 1300° F. for an extended period of time.

The effectiveness of the bath depends on continual oxidation of NaCN to sodium cyanate. Hoods that interfere with the flow of plenty of air over the top of the bath should be avoided, since the oxygen in the air is the sole means for the oxidation of cyanide. The formation of black scum will reduce cyanate because scum is nearly pure carbon and it is an effective reducing agent. It can be eliminated by adding laundry or corn starch to the top of a scumming bath, which increases the amount of scum, makes it coagulate, and permits it to be easily skimmed off.

Salt baths used for hardening and annealing steels have an advantage over lead baths, because salts do not adhere to steel; also, they require no charcoal cover and evolve no toxic fumes when operating at 1600° F. or higher.

Temperature Ranges

For steels, the baths may be mixtures of alkali carbonates and chloride for treatments at 1200° to 1650° F.; mixtures of alkali chlorides when used at 1400° to 1650° F.; and mixtures of barium, sodium and potassium chlorides when used at 1200° to 1800° F. The first two types need 2% of borax to reduce the iron oxide. For high-speed steels, a silicate bath has been developed.

The 30% sodium cyanide bath is used for reheating carburized work and for hardening high- and medium-carbon steels. In this type of bath no decarburization will take place during the heating cycle. This is important when no grinding is to be done.

Cyanide reheat gives gear steels a slight increase in surface hardness over that obtained by conventional methods. Certain machine parts are carburized and then have a section of the case removed by machining before hardening. Such parts may not be hardened from reheat, as they will pick up sufficient hardness, where not desirable, to render them unfit for machining.

Low-temperature baths are of either alkali nitrates, or a mixture of nitrates and nitrites. Such baths have melting points from 285° to 585° F. and may be used from 20° above their liquefaction points to 1100° F. if nitrites are present, and up to 1200° F. if only nitrates. VSP (2a)

Atomic-Hydrogen-Welded Aircraft

"Atomic Hydrogen Welding in Aircraft Production." R. Smallman-Tew. *Trans. Inst. Welding, London,* Vol. 4, Jan. 1941, pp. 22-28. Descriptive.

The replacement of an unsatisfactory oxyacetylene process (for making cruciform welds in tubes of unequal thickness) with a satisfactory atomic hydrogen process, is described. Justification for the purchase of new equipment was its applicability to the production of a welded assembly to replace prototype forgings, which are expensive to produce, particularly for short runs.

Production of the forging replacements is simplified by purchase of the alloy steel in the softened condition. The parts are bent to shape and welded, and then heat treated for high mechanical strength.

It is more difficult for an experienced arc welder to acquire the technique of atomic hydrogen welding than it is for the oxyacetylene welder. No slag is formed in the atomic hydrogen process and any scale on the surface is reduced. The speed of welding is slightly increased over that of the oxyacetylene process, but it is much slower than arc welding.

The absorption of hydrogen by the weld is controllable by the technique of the welder; overheating of the weld leads to excessive gas absorption. Weld profiles are better than with arc welding and there is almost complete freedom from welding cracks. The alloy steel which is generally used in England for such welded aircraft parts is a 1½% Mn steel. WB (2a)

Carburized Stainless Steels

Case-Hardening of Stainless Chromium Steels. ("Einsatzhärten von nichtrostenden Chromstählen") R. Weihrich. *Stahl u. Eisen,* Vol. 61, Jan. 23, 1941, pp. 83-84. Practical.

On carburizing low-carbon, 15% Cr stainless steels, very high carbon unevenly carburized layers containing massive carbides may be obtained. This can be obviated by using fresh carburizer and carburizing at temperatures not over about 1725° F.

Partly spent carburizer may contain oxidizing substances, which readily form a greenish layer on the stainless steel whereas they do not injure ordinary steel. Such carburizer may be revived by heating in a closed container in the absence of air to about 1650° F.

Examples are given where the use of fresh commercial carburizer, such as activated charcoal, gave very uniform 1% C cases, 0.25-0.35 in. deep, 57-59 Rockwell C after hardening, with good corrosion resistance, on 15% Cr steel carburized at 1725° F. for 6 hrs. SE (2a)

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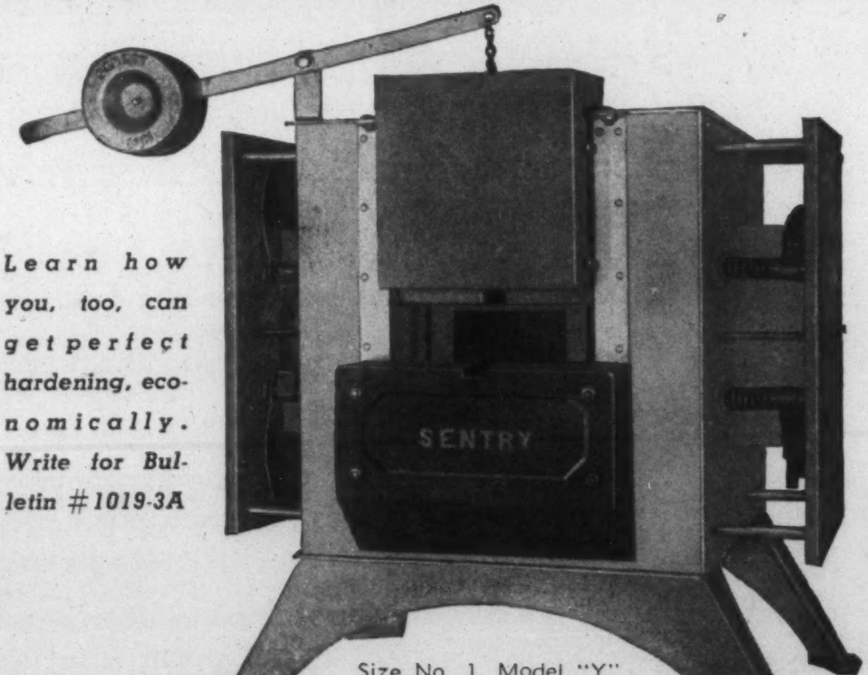

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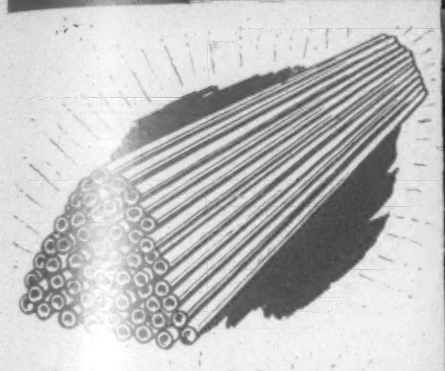

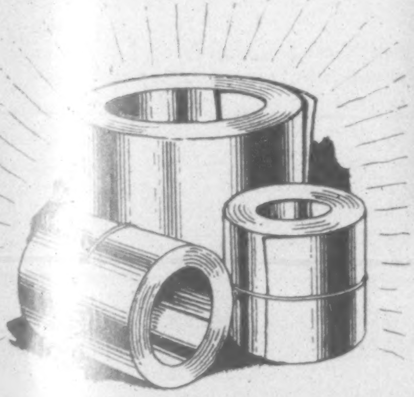

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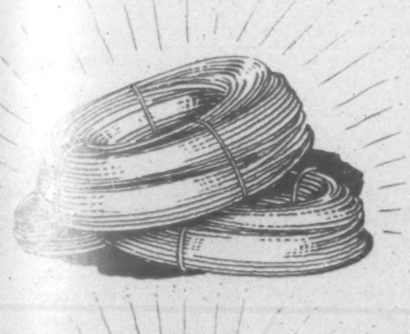

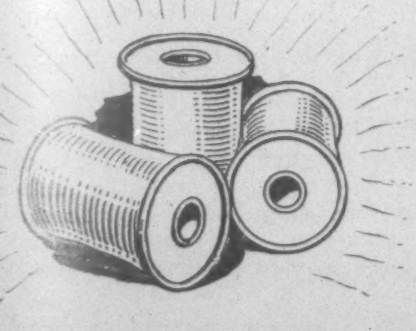

Steels for Hard-Chromium Plating

CHANGES OF STRENGTH OF VARIOUS STEELS DUE TO HYDROGEN ABSORPTION DURING HARD-CHROMIUM PLATING ("Ueber die Änderung der Festigkeit verschiedener Stähle durch Wasserstoffaufnahme bei der Hartverchromung") M. SCHMIDT & K. GEBAUER. *Techn. Zentralbl. prakt. Metallbearbeitung.*, Vol. 50, Sept. 1940, p. 466; Oct. 1940, pp. 525-526. Original research.

The object of this work was to determine (a) whether there are steels particularly susceptible to hydrogen embrittlement and (b) whether hydrogen may be expelled by a low-temperature anneal after hard-chromium plating.

Steel rods of 0.4 in. diam. and 4.5 in. length were chromium-plated for 2 hrs. in a hard-chromium-plating solution at 50 amps./dm.^{2} and 130° F. One half of the samples were then heated for 30 min. to 400° F. (or to only 350° F. if the tempering before chromium plating was at 350° F.). The loss of strength was determined by bending.

The loss of strength due to hydrogen absorption in hard-chromium plating is more pronounced in plain carbon steels than in high-speed tool steels. The low-alloy tool steels show a moderate loss of bending strength. Two steels were practically unaffected by hydrogen—one containing 0.4% C, 1 Si, 1 Cr and 2 W, and the other 0.6% C, 1.6 Cr. 2.5 W, 0.7 Si. They are well adapted for complicated parts and dies tending to form cracks in chromium plating.

The heat treatment by drawing has hardly any effect. The "hot work" die steels and 2 alloy carburizing steels (3.5% Ni, 0.75 Cr; and 1.2% Cr, 0.25 Mo) were also scarcely affected by hydrogen. Heating to 400° F. *after* chromium plating is to be recommended as it raises the strength, particularly after severe hydrogen embrittlement.

The opinion generally prevailing in the chromium-plating shop that carbon steels lend themselves better to plating is not valid, as in view of their loss of strength, they are really inferior to alloy steels for this purpose. EF (2a)

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Basket of Inconel used in Pit Type Nitriding furnace. (Courtesy—Westinghouse Electric & Mfg. Company.)

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Heat Treatment Stresses

"MAGNITUDE AND CHARACTER OF RESIDUAL TANGENTIAL STRESSES AS A FUNCTION OF HEAT TREATMENT." E. S. TOVPENETS. *Vestnik Metalloprom.*, Vol. 20, Oct. 1940, pp. 41-44. In Russian. Experimental.

Tubes of alloy steel containing 0.35% C, 0.95 Cr, 3.09 Ni and 0.37% Mo were heat-treated under varying conditions and the residual tangential stresses determined. It was established that the rate of cooling affects the magnitude of the stresses to a greater extent than the temperature from which the cooling commences.

No thermal stresses were produced by cooling from 850° F. or even 1150° F. in oil at 200° F. The mixed (hardening) stresses resulting from quenching in water at 75° F. with immediate transfer to hot oil at 200° F. exceed the stresses produced by (a) quenching in oil at 200° F. from a temperature above Ac_3 (1500° F.) and by (b) quenching from 1150° F.; in the latter case, the excess is considerable, and reaches up to 42,000 lbs./in.^{2}

The stresses produced by hardening increase with the rate of cooling and temperature of hardening. The gamma to alpha transformation produces no stresses if it occurs during holding at temperatures below A_1 (850° F. and higher). If the transformation takes place during the period of relatively rapid cooling, it results in considerable stresses, which are apparently the causes of cracking and warping.

Stresses produced (after tempering) by cooling in hot oil (from tempering temperature as low as 750° F.) are purely structural. These occur during the cooling period as a result of the transformation of the residual austenite, and their value is insignificant. BZK (2a)

Grinding of Printing Plates

"INFLUENCE OF GRINDING TREATMENTS ON THE SURFACE HARDNESS OF INTAGLIO PRINTING PLATES OF 0.33-PER CENT CARBON STEEL. HARRY K. HERSCHMAN & FREDERICK KNOOP. *J. Res. Natl. Bur. Standards,* Vol. 26, Mar. 1941, pp. 261-272. Investigation.

Mechanical-transfer plates of 0.33% C steel having different metallographic structures were investigated to determine the influence of different grinding conditions on the surface hardness of the steel. Hardness indentation tests were made with different loads on an elongated pyramidal-diamond indenter developed at the National Bureau of Standards. The geometrical irregularities of the ground surfaces evaluated by the "tracer" method as the root-mean-square average deviation from a nominal surface were considered with respect to their influence on the accuracy of the hardness measurements.

Experimental data are presented to show that the hardness of the surface metal, dis-

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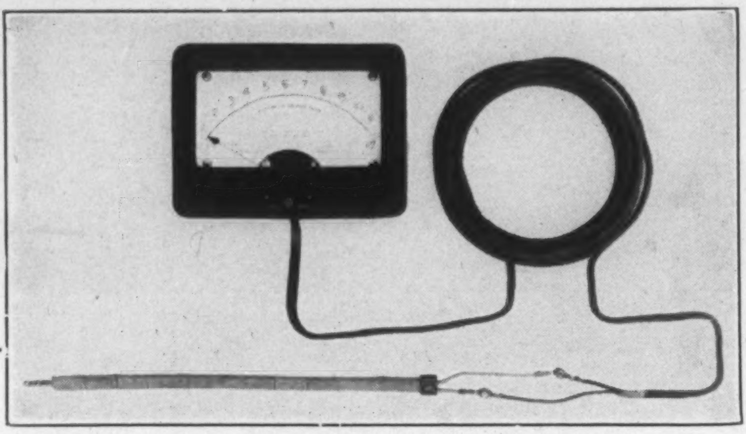

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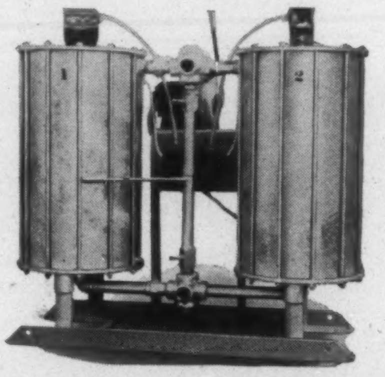

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tinguished from that of the underlying metal, may be significantly influenced by (1) the cooling conditions during grinding, (2) the depth of cuts, and (3) the grain size of the abrasive. However, the rate at which the stone passed over the specimens did not appear to influence the hardening effects.

The results obtained within the limitations of the tests suggested that surface hardness is independent of the geometrical condition of the surface. However, the accuracy of the measurements of surface hardness by indentation means may be influenced by the degree of finish of the surface.

The hardening effects of the grinding treatments on the steel investigated did not appear to be influenced by differences of the microstructures of the material. The hardness data secured suggested that the most significant hardening effects of grinding are superficial and that these influences are progressively less for the successively deeper adjacent layers of the steel.
WAT (2a)

Inhibitors in Electro-Pickling

THE EFFECT OF INHIBITORS ON THE CATHODIC PICKLING OF STEEL SHEETS ("Der Einfluss von Sparbeizen auf das kathodische Beizen von Stahlblechen") W. BAUKLOH & I. KARNATH. *Korrosion u. Metallschutz,* Vol. 16, Dec. 1940, pp. 418-421. Experimental.

Hydrogen absorption in steel during pickling depends largely on the surface nature of the steel; activated spots absorb less gas, because at those points the formation of H_2 from H is increased, and the molecular gas is not absorbed. On the other hand, such impurities in the surface as arsenic, antimony, etc. prevent this formation and thus favor the absorption of atomic H.

The authors investigated the extent to which the addition of inhibitors to the electrolyte for the cathodic pickling of steel sheets contributes to hydrogen absorption by harmful surface impurities. The pickling acid was sulphuric of 0.1 and 1.0 vol. %, and 2 different proprietary German inhibitors were used (B_1 of O. Friedrich, and B_2—"Novatol-Essenz"—of Langbein-Pfanhauser) in concentrations of 0.01, 0.1, 1.0 and 10% by vol. The pickling time ranged from ½ to 4 hrs.

The effect of pickling was determined by observing changes in deep-drawability, rather than by noting the hydrogen absorption directly, on 2¾ in. x 2¾ in. sheets containing 0.09% C, 0.39 Mn, 0.022 P and 0.028 S. The basis of comparison used was the behavior of the steel when non-electrolytically pickled in pure sulphuric acid.

One inhibitor (B_1) caused in the early stages of pickling a noticeable deterioration of the deep-drawability, but the quality was later recovered (by releasing hydrogen) on extended pickling. All concentrations of this inhibitor showed lower values (poorer performance) than the untreated acid. The other inhibitor (B_2) gave in both 0.1 and 1% concentrations better values of deep-drawability than the pure acid; the bath did not foam and remained clear and colorless. The introduction of arsenic or phosphorus as impurities in small amounts reduced the deep-drawability, although arsenic in non-electrolytic pickling with uninhibited baths exerts a favorable effect.

Pickling with additions of strongly oxidizing substances (nitric acid or potassium bichromate) showed a decided suppression of the hydrogen danger in both electrolytic and non-electrolytic pickling. Ha (2a)

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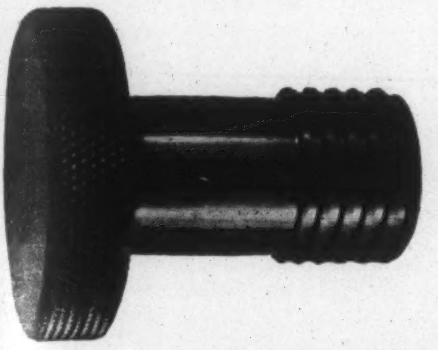

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Welding Cast Iron

A Composite

It is ordinarily considered wise to preheat iron castings that must be welded for repair or original construction purposes. Preheating is not always convenient or economical, however, and foolproof methods of welding cast iron without preheat would be highly desirable.

The Germans have given much attention to this—they call it the "cold-welding" of cast iron—and 2 recent articles have reported experiments and experience in this type of welding, using cast iron welding rod in all cases. Thus, G. KRITZLER & G. ARNOLD ("Beitrag zur Frage der Kaltschweissung von legiertem und unlegiertem Gusseisen verschiedener Güteklassen," *Autogene Metallbearbeit,* Vol. 34, Feb. 1, 1941, pp. 49-61; Feb. 15, 1941, pp. 65-76) have investigated at some length the "cold" welding of several types of plain and alloy cast iron.

For the tests, 3 types of cast iron were used, in the form of plates 16.5 in. x 20 in. x 0.4 in.: (1) a 3.32% T.C., 3.23 graphite, 3.66 Si unalloyed iron; (2) a 3.15% T.C., 2.58 graphite, 2.32 Si unalloyed iron; and (3) a molybdenum iron with 3.09% T.C., 2.37 graphite, 1.75 Si and 0.56 Mo. The welding rods were plain cast irons with 3.05-3.18% T.C., 1.95-2.51 graphite and 3.30-4.00 Si.

The welding operation (acetylene welding was used) caused warpage of the plates; if the plates were held firmly, linear contraction can take place at the start of the operation parallel to the weld, but as welding is continued, positive elongation occurs. No satisfactory explanation could be given for this fact. Unclamped plates shrink during all stages of welding. The transverse shrinking of clamped plates differs from that of unclamped plates in that the former has a pronounced maximum in the shrinking; this difference does not exist with steel.

Welding of cast iron without general preheating will be satisfactory if the weld is not too long and if the base material surrounding the starting end of the weld is preheated slightly by the burner to minimize stresses. In the direction perpendicular to the weld, the base material must be able to follow the shrinking in order to prevent the occurrence of pure tensile stresses in the welded joint.

The mechanical strengths obtained in the weld and expressed as a percent of the values for the unwelded parent metal were found to be as shown in the Table.

Property	Type of Iron		
	1	2	3
Tensile strength	96%	70%	69%
Deflection	75	51	56
Static bending strength	85	58	77
Fatigue strength	91	75	64

These values represent the averages of all welds made in the experiments. The greatest Brinell hardness—about 250-270 —was found in the transition zones. However, all welds could easily be machined. Metallographic examination of the welds showed a zone in addition to the weld metal that was affected by the welding process and strongly carburized, and the graphite appeared in finer distribution than in the parent material. The various welding conditions had only a slight effect on structural change.

X-ray examination of the welds revealed some differences in the 3 types of cast iron. There were fewer inclusions

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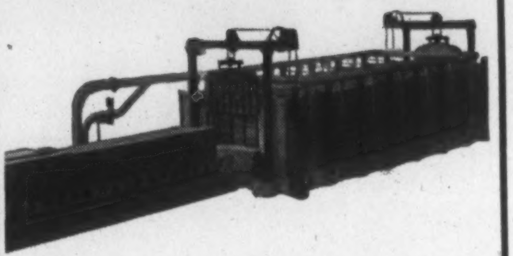

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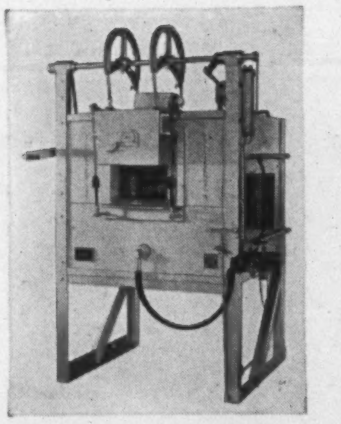

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and gas blisters in the alloyed type (3) than in the others.

A special technique involving the spraying-on of certain metals before welding cast iron is described by P. KRUG ("Kaltschweissung von Gusseisen," *Z. ver. deut. Ing.*, Vol. 84, Oct. 12, 1940, pp. 777-783). Metallizing the sides to be welded with aluminum, lead, zinc, nickel or copper prevents carburization and excessive hardening and embrittlement. Much stronger welds with softer transition zones are obtained in this fashion. Nickel or copper gave better results than aluminum, lead or zinc. Ha (2a)

Arc Welding High Strength Steels

"THE ARC WELDING OF HIGH TENSILE ALLOY STEELS. PART I—THE CRACKING PROBLEM WITH SPECIAL REFERENCE TO THERMAL CHARACTERISTICS," E. C. ROLLASON. "PART II—BASE METAL CRACKING," E. C. ROLLASON & A. H. COTTRELL. "PART III—THE EFFECT OF DELAYED COOLING ON PROPERTIES OF MARTENSITE, AND A MAGNETIC TEST FOR DETERMINING THE TRANSFORMATION TEMPERATURE," A. H. COTTRELL, K. WINTERTON & D. D. CROWTHER. *Trans. Inst. Welding, London,* Vol. 4, Jan. 1941, pp. 3-21. Review and investigation.

The problem of welding high tensile steels lies in preventing hot cracks in the weld and cold cracks in the hardened base metal. An attempt was made to obtain thermal data for 2 steels: (a) 6% Cr, 0.5 Mo, and (b) 3.5% Ni with chromium and molybdenum. The brittle constituents in which cracks usually occur on welding form at 400° to 285° F. for nickel-chromium-molybdenum and 660° to 500° for chromium-molybdenum steel.

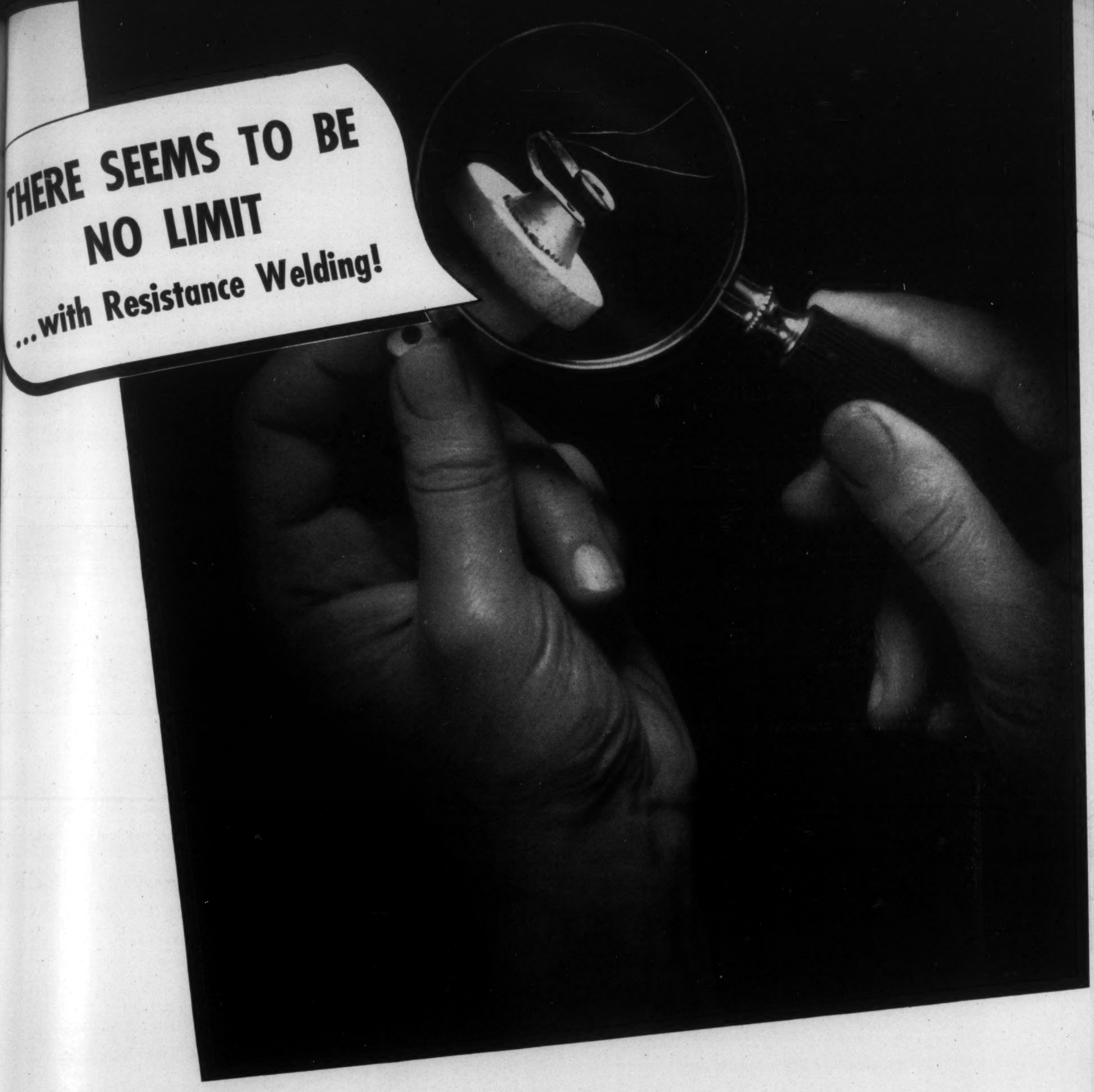
Causes of Cracks

High tensile weld metal is likely to have (a) hot cracks along columnar crystal boundaries and in the throat where columnar crystals meet to form a weak plane; (b) coarse columnar or ingotic structure, not refined readily by subsequent runs as in the case of mild steel; (c) entrapped impurities, especially refractory oxides arising from alloying elements, *e.g.* Cr_2O_3. Some of these troubles may be minimized by the use of austenitic welding rod.

Cracking in the base metal may be due to the occurrence of phase changes, during cooling, at a relatively low temperature. For the nickel-chromium-molybdenum steel it was found that there is a sharp lowering of the critical temperature as the initial soaking temperature is raised from 1435° F. to 1525° F. and to 1650° F. for the chromium-molybdenum steel. The only practical method of producing "pearlitic" structures in some of the alloy steels whose austenite has been stabilized by the high temperature during welding is to permit the transformation to martensite to take place and then reheat.

Several different methods of welding were considered. Preheating to 750° F., cooling the weld to 520° F. for a considerable amount of martensite formation, and then reheating to 1200°-1400° F. reduces internal stress, and the martensite will not be subjected to full contraction stresses. Preheating or post-heating near the Ar" temperature is good general practice to reduce temperature gradient.

Cracking tests were made by heating the end of a rod of the steels with an oxy-acetylene torch while water-cooling the other end and oil-quenching thereafter; the hardness rose to 550 Vickers without cracks occurring, showing that external tensile stress or restraint during welding must be applied to the martensitic structure to produce cracking. Hot cracking of



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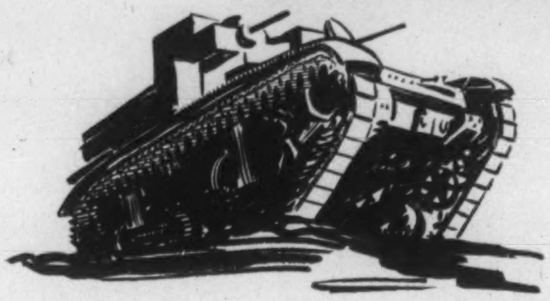

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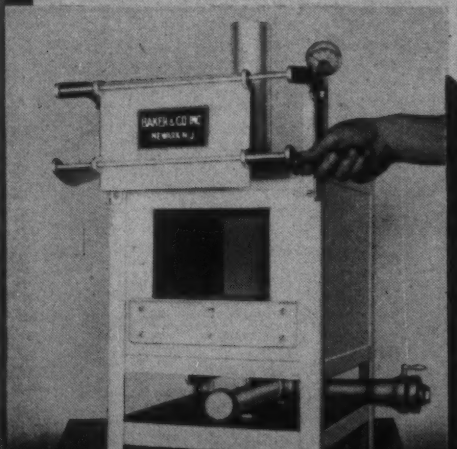

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austenitic welds was found to occur where the hardness exceeded 250 Vickers, due to dilution with the base metal. Cracking along columnar crystals of the weld was frequent in welds of 4-6% Cr steel. Preheating to 480° and 650° F. prevented cracking but only slightly decreased the hardness.

Plastic deformation relieves shrinkage strain down to about 925° F. but elastic strain is built up on further cooling and cracking occurs in martensite. In welding thick plates the triaxial stresses prevent relief of strains by normal plastic yielding.

Welding tests were made on 3 low-alloy steels, welded with high tensile and special "18 & 8" electrodes in a restrained type of butt welding test. Cracking occurs at temperatures of 95°-210° F., the temperature being measured at a point at such a distance from the fusion line that the maximum temperature attained is only 930° F.

Improving Toughness

Cracking is thus not caused solely by the volume change associated with the formation of martensite, but occurs at a much lower temperature. The stress in transverse direction required to produce cracking is of the order of 110,000 lbs/in.^{2}. Stress is relieved to a certain extent in all welds by creep under contractural stress. down to about 475° F. Preheating and use of austenitic electrodes prevent cracking, the first by extending the creep period, the second by providing a toughened martensite. Delayed cooling from 475° F. also prevents cracking without reducing the hardness, because martensite is toughened by tempering.

The effect of delayed cooling on the area under the stress-strain curve was noted for two samples. Air cooling from 1000° C. with a fan simulated the cooling rate of the base metal during welding. One sample was immersed in oil at 300° F. for 10 min. after its temperature had dropped to this level, and then water-quenched. This sample had considerably increased toughness (22%) as measured by the area under the curve.

Varied time of delay in cooling (0-45 minutes) and various temperatures of arrest (210°, 300°, 400°, 475° F.) were investigated, and toughness found to increase rapidly for the first 10 min. and more slowly thereafter. Greater toughness was found for the treatment at 210° F. and at 300° F., which gave tempered martensite, than for treatments at 400° and 475° F., which gave lower bainite structures.

The transformation temperature on cooling from welding heat was determined with a magnetic tester, giving fluxmeter readings which are plotted against temperature in the zone under study. Martensite transformation temperatures were determined as occurring between 410° and 535° F. test. Transformation in the weld metal of a shielded arc electrode was found to occur at 955° to 935° F., to give upper bainite. WB (2a)

2b. Non-Ferrous

Welding Magnesium Castings

WELDING OF MAGNESIUM CASTINGS, I ("Schweissen von Magnesiumguss, I") KLAUSS GRASSMANN & JOHANNES BRANDIS. Z. METALLKUNDE, Vol. 33, Jan. 1941, pp. 38-43. Original research.

Except for the binary 1.5%-Mn magnesium alloys, magnesium alloys as a class (and particularly those containing aluminum or zinc, or both) offer difficulties in welding. The authors concentrated on the German standard DIN 1717 type of magnesium alloys (1-10% Al, 0.5-3 Zn, 0.3 Mn) and particularly on the problem of corrosion through inclusion of welding fluxes.

Such inclusions usually affect considerable areas in spite of their own minuteness. The worst offenders are salt solutions, especially chlorides; sulphates, phosphates and nitrates are less destructive. These salts penetrate into the fine fissures, flaws and pores usually encountered in magnesium castings. With commercial (German) fluxes, typical salt corrosion was found in the welds, sometimes after waiting several months, in spite of washing in hot water, HNO_3 or boiling in a potassium bichromate solution.

The experiments were conducted along 2 lines: (a) using salt mixtures that can be readily removed from the weld, and (b) using salt mixtures that have no corroding effect upon magnesium even if inclusions are retained. As to (a), mixtures of potassium chloride, sodium chloride and cryolite were employed, and the welds exposed for 4 wks. to moist steam. No defects were detected then, but after additional 2-4 months, 15% of the welds showed corrosion defects.

Regarding (b), magnesium samples (wrought and cast) were placed for 15 days in 1% suspensions of the authors' flux (of the fluoride-type) and of hygroscopic and non-hygroscopic fluxes available on the (German) market. The fluorides are completely neutral, while the fluxes of the chloride type vigorously attacked the samples, particularly the castings.

No corrosion defects were noticed on welds made with fluoride fluxes after several months. The results were confirmed by drilling holes into magnesium castings, filling them with fluxes of either the fluoride or the chloride type, and closing up the holes by welding. With the chlorides, corrosion was noticed after 24 hrs. No defects occurred with the fluoride fluxes, even after admitting air by cutting the castings open.

The fluoride-base fluxes are claimed to form a protective atmosphere during welding, through partial volatilization, which prevents burning of the liquid metal. Weight loss tests for 90 min. on magnesium fluoride, lithium fluoride, and a mixture of 66% magnesium fluoride and 34% lithium fluoride, showed losses of 16%, 11% and 4%, respectively, at 1825° F. Magnesium fluoride melts at 2275° F. and needs additions to lower its melting point.

EF (2b)

Gold Plating

"MODERN GOLD PLATING, PARTS I TO VII." JOSEPH B. KUSHNER. *Products Finishing*, Vol. 4, Sept. 1940, pp. 30-38; Vol. 5, Oct. 1940, pp. 78-86; Nov. 1940, pp. 42-50; Dec. 1940, pp. 16-30; Jan. 1941, pp. 20-28; Feb. 1941, pp. 30-46; Mar. 1941, pp. 24-40. Practical.

The usual practice today is to buy gold for plating in prepared salts, which can be dissolved to make the plating solution. If it is desired, the solutions can also be prepared from gold by either dissolving the metal electrolytically in a cyanide electrolyte or by dissolving it in aqua regia and treating it successively with sodium hydroxide and potassium cyanide to produce a solution of the desired concentration.

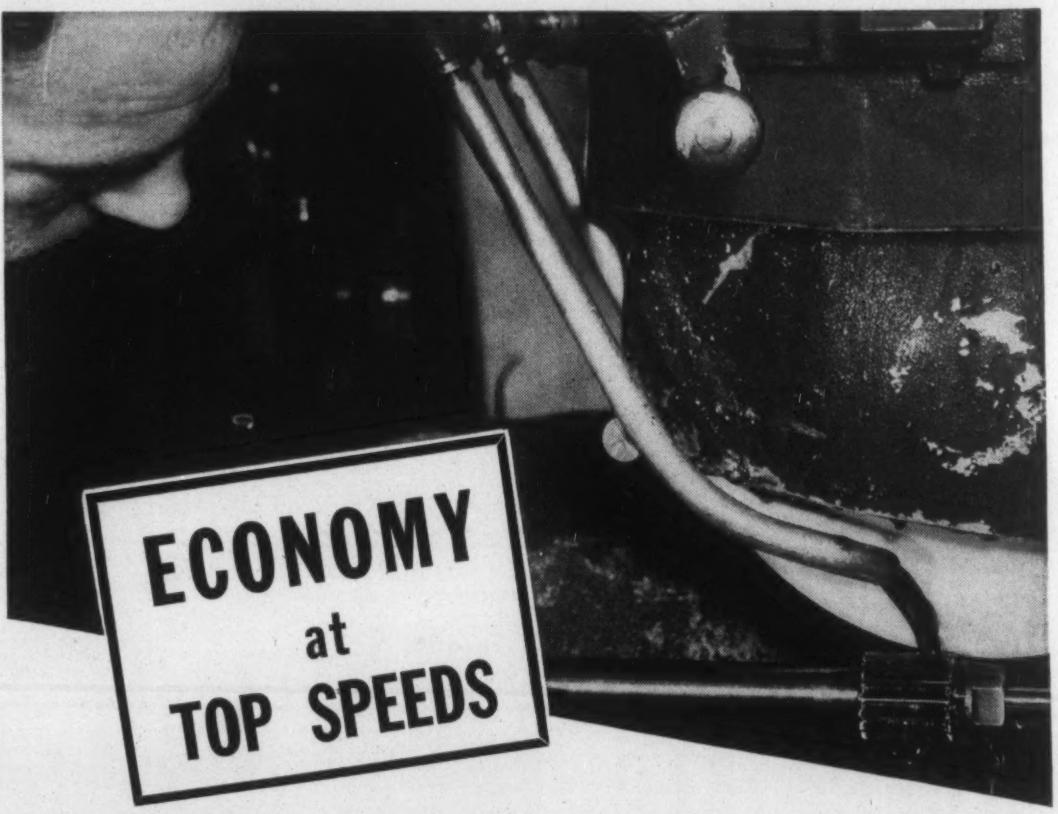
Gold can be deposited by any one of 3 methods. Immersion gilding involves chemical displacement, and makes use of simple cyanide solutions. It is most successfully used on small copper or brass articles.

The second method, salt water gilding, uses an internal e.m.f. developed between a zinc anode and the work to be plated; the anode solution is commonly made from sodium chloride. The work is hung in a gold plating solution, separated from the anode solution by a porous cup. A copper cross bar completes the circuit. For maximum production, externally applied e.m.f.'s are used with a cyanide electrolyte. The deposits are fine-grained. Potassium cyanide appears to give better results than the sodium salt.

The present policy of plating in small batches is considered costly because of gold fluctuations in the bath, current density changes, solution of anodes and contamination of the work which all cause changes in the deposit characteristics. Color control is extremely complicated. Gold deposits are hard to match because the eye is particularly sensitive to yellow light. Among the physical factors that must be controlled are current density, agitation, temperature, racking of the work and nature of the base metal.

As compared to rolled gold, plated gold alloys are more dense and more prone to corrosion. Disadvantages of rolled gold are the losses in stamping and "raw" edges. However, heavy gold plate is hard to control for color, and its wear resistance is low.

Heat treating electrodeposited gold plate to form a solid solution alloy is known as the Bek process. At the present time,



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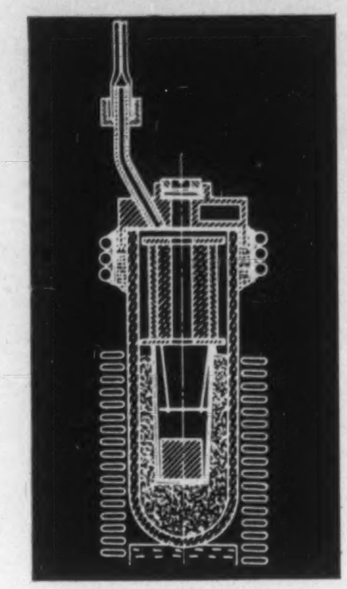

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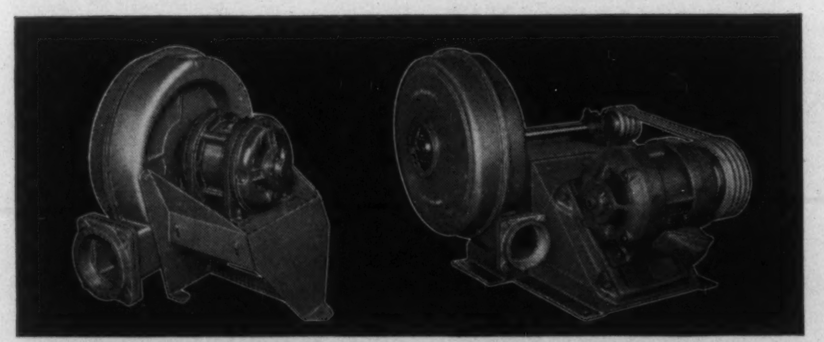

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gold alloys are deposited to lower the heat treating time. Corrosion and wear resistance are improved by the heat treatment. Age-hardening gold alloys are stronger than steel. A hard plate can be achieved by plating on "Z" nickel and then aging at 1650° F. for 6-9 hrs.

Gold plating in barrels is recommended for some purposes because the cost is low, due to short plating times and the thin gold deposits required. Color variations are kept to a minimum by improving the electrical and mechanical characteristics of the barrel PCR (2b)

Thermal "Soaking" of Light Metals

The Temperature Distribution in Light Metal Ingots on Heating and Cooling ("Ueber die Temperaturverteilung in Leichtmetallblöcken beim Erhitzen und Abkühlen) Walter Roth. *Z. Metallkunde*, Vol. 33, Jan. 1941, pp. 13-15. Research.

The author derives formulas expressing the temperature distribution in round light metal objects during heating in stationary air and in a salt bath and during cooling in stationary air and quenching in water.

The opinion prevailing in the shop that fabrication difficulties are to be blamed on insufficient soaking of light metal parts is refuted. Even with bars of 1.5 in. diam. the temperature gradient between surface and center does not exceed 18° F. This temperature gradient is eliminated within a few minutes during heating in a salt bath or on water-quenching. EF (2b)

Spot Welding Brass

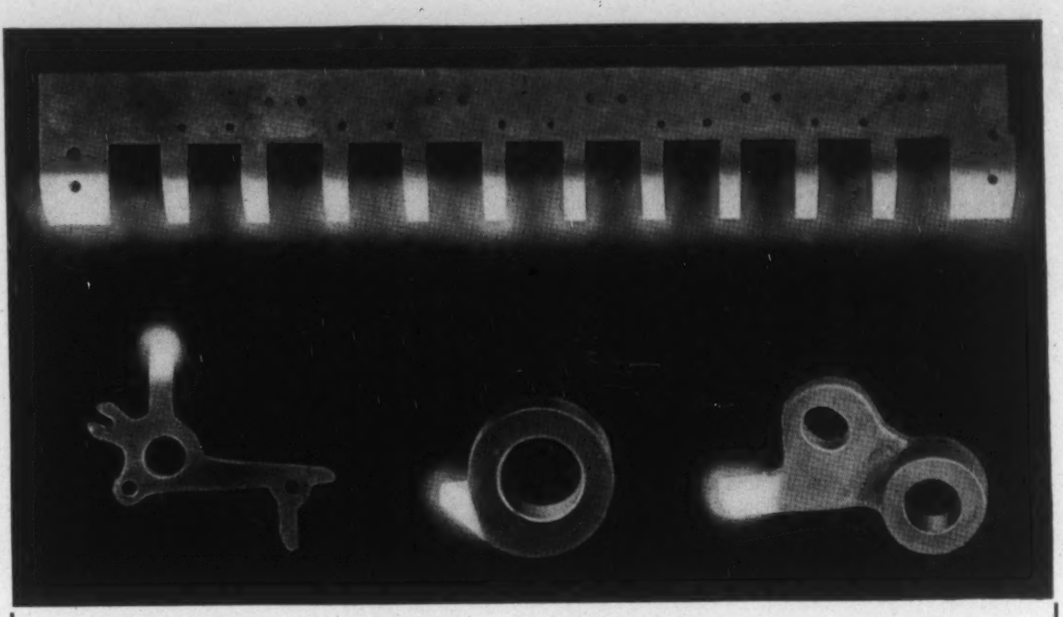
"A Study of Spot Welding on a Copper Base Alloy." M. L. Wood, J. Babin & O. B. Atkin (Chase Brass & Copper Co.) *Welding J., N. Y.*, Vol. 20, Mar. 1941, pp. 149s-159s. Research report.

The spot welding of an alloy containing 77% Cu, 1 Si and 22 Zn was studied. The variables were surface preparation, point size, shape and pressure, point material, gage of alloy sheet, and welding time (no. of cycles). Also, the effect of alloying additions of aluminum, silicon, manganese, phosphorus, iron, silicon-manganese and aluminum-manganese to 70-30 brass on the strength of the resultant weld was surveyed.

The torsional shear test was found to have a high sensitivity in indicating the variation of weld strength with change in surface preparation, point size, shape and material, and also with small changes in composition of the brasses. A fair prediction of weld strength can be made from the microstructure since strength is directly related to the area of cast metal shared by the two sheets.

For spot welding silicon brasses flat points of high conductivity are recommended. Unit electrode pressures of the order of 15,000 lbs./in.^{2} will permit welds to be made at low inputs, and the welds are quite uniform in strength over a range of input. Metal of 0.020 to 0.060 in. gage has its maximum strength with 3/16 in. flat points and 22,000 secondary amperes. Six cycles, recommended for the welding time, is a compromise between 4 cycles (frequent unsoundness) and 8 cycles (tends to give point troubles). An upper limit to satisfactory gage of sheet may exist, owing to the high vapor pressure of zinc in the alloy.

Surface preparation is considered a highly important variable. Apart from uniformity of surface and cost, there is no brief for any method of surface preparation, provided that a satisfactory weld structure can be produced. The different



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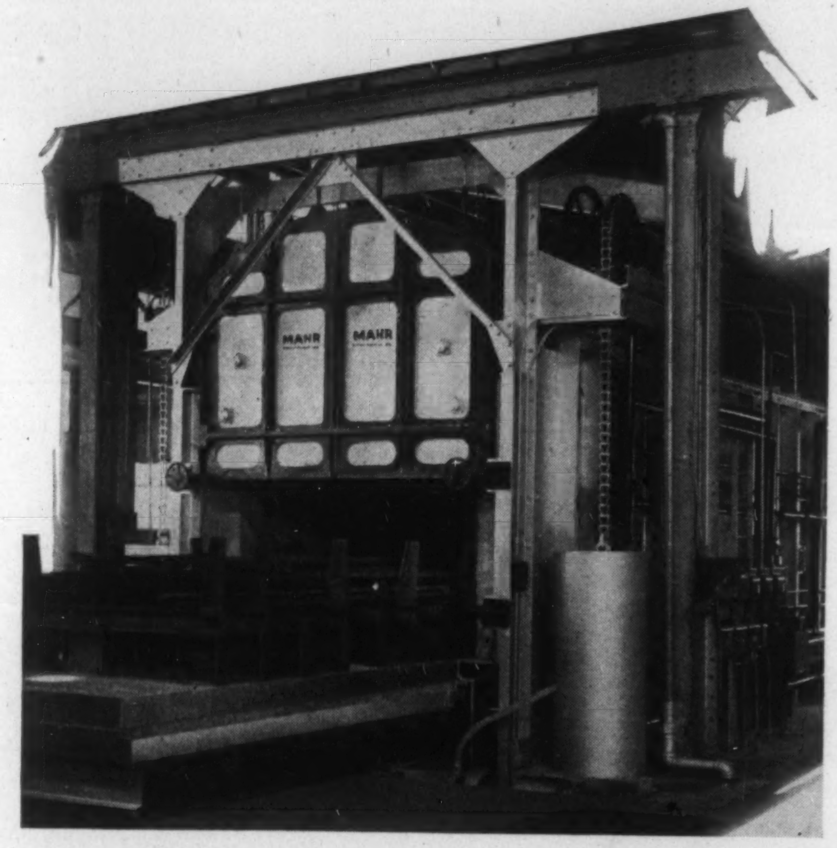

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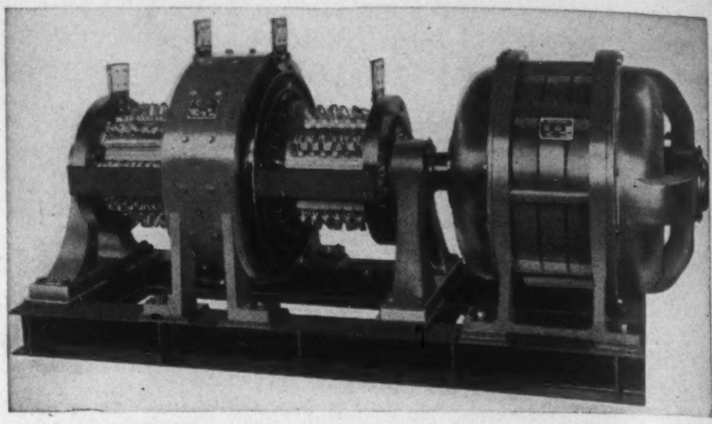

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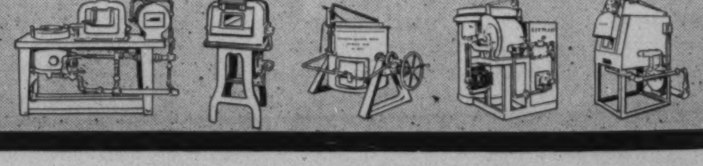

surface treatments used in the study were pickling in 10% sulphuric acid, which dissolves metallic oxides but tends to leave a film high in silicon from the annealing scale; bichromate dipping after pickling; bright dipping in mixtures of sulphuric, hydrochloric and nitric acids; chloride-dipping in a solution of iron and magnesium chlorides in hydrochloric acid containing sodium chlorate (to regenerate $FeCl_3$); buffing with greaseless compound after chloride dip; and dry rolling after chloride dip, to produce a highly burnished, bright surface (but at considerable cost).

Comparisons of torsional shear strength and maximum angle of twist indicate the highest values in general for the chloride-dipped work and for the combination of chloride dip with buffing or dry rolling treatments. WB (2b)

Welding Lead and Its Alloys

"Lead Welding—A Review of the Literature to Jan. 1, 1940." W. Spraragen & G. E. Claussen. *Welding J., N. Y.*, Vol. 20, Feb. 1941, pp. 81s-92s. Correlated abstract. 157 references.

Thicknesses of lead from 1/32 to 1¼ in. have been gas-welded. Lead chambers for sulphuric acid manufacture and other lead chemical-apparatus have been welded. The torches used have been oxy-hydrogen, air-hydrogen, oxyacetylene, atomic hydrogen, and the arc. In welding lead the filler rod should have the same composition as the base metal and should be free from tin and antimony.

The welding of lead can be done in flat, vertical or overhead position, the fused metal being held in place by capillarity in the overhead position. The mechanical properties of the weld deposit can be increased by peening to refine the cast structure. Lead alloys such as those with 4-6% Sb; 0.05-0.065 Te; 1.5 Sn, 0.25 Cd; 0.25 Sb, 0.25 Ca; and all lead-tin alloys are easily welded. The welding of lead to brass and iron can be accomplished by first tinning the base metal.

The chief metallurigcal problem in lead welding is to prevent oxide formation, which interferes with the merging of the lead globules and may cover scarves sufficiently to prevent wetting and penetration. No truly practical flux has been found for lead welding. Where preferential corrosion of lead weld metal occurs, it indicates that the filler rod contained oxides, that an oxidizing flame was used or that the scarves were not shaven.

Lead also may be welded by resistance spot welding, by pressure welding, by burning-on or casting-on, and by the carbon arc. WB (2b)

Welding Precious Metals

"Welding Gold, Silver and Platinum. A Review of the Literature to Jan. 1, 1940." W. Spraragen & G. E. Claussen. *Welding J., N. Y.*, Vol. 20, Mar. 1941, pp. 121s-135s. Review, covering welding and soldering; 155 references.

Gold and its alloys are welded with small torches and oxy-city gas, air-city gas, oxyacetylene and other flames using borax, boric acid or mixtures for flux. Resistance and pressure welds are made, the latter to a considerable extent for the gold-cladding of base metals.

Soldering is performed on gold alloys by dentists and jewelers with hard, medium or soft solder containing 62.5%, 50% and 42.5% Au, respectively. The same type of flux as in gas welding is used and pickling is employed after soldering, to remove the tarnish. The tensile strength of the joint is approximately that of the solder. Several authorities consider 2 useful criteria of a good joint to be continuity of grain structure across the soldered joint and the absence of dendritic structure in etched sections. Heating for soldering is done with gas torch or electrical resistance.

The welding of silver is more difficult because of its high thermal conductivity. Absorption of oxygen makes the welds porous and brittle, and therefore neutral flame and flux are used. Silver-clad iron has been welded but silver-clad copper is difficult to weld unless there is an intermediate layer of a high-melting-point metal (iron or nickel) to prevent dilution of the silver layer. Spot and seam welding of silver to iron, brass or cadmium-plated iron has been successful.

Pressure welding by forging or hot-rolling has been used to weld silver to Invar, nickel and iron. Soldering of silver with silver-copper-zinc solder has been practiced with gas torch or electric resistance as the source of heat. Both the oxy-hydrogen and atomic hydrogen processes have also been employed for welding silver.

For welding platinum the torches used are oxy-hydrogen, oxyacetylene and atomic hydrogen and no flux is required. Platinum-copper and platinum-nickel welds have been made by a combination of torch heating and pressure, using flux for protection of the base metal. WB (2b)

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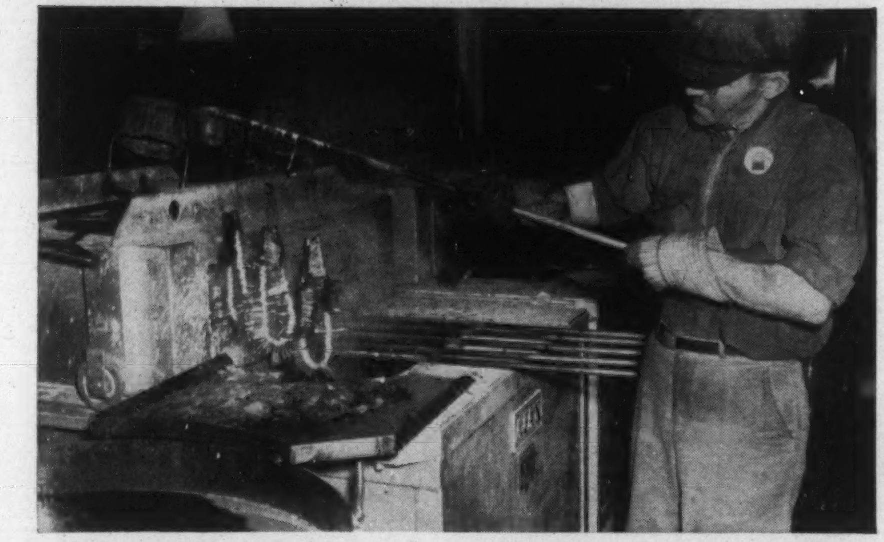

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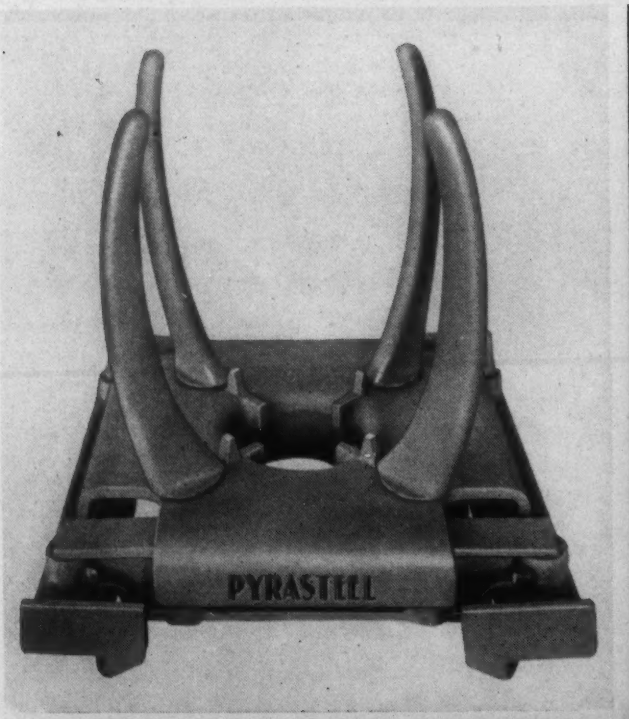

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Priorities and Substitutes

"The War of Metals." Walter Mitchell, Jr. Dun & Bradstreet, Inc., New York, May 1941, 11 pp. Survey.

Metal shortages such as the defense program is now developing can affect the course of all industry and the life of the American consuming public profoundly in the next few months. Little is gained by substituting one metal for another when the substitute metal turns out also to be "critical." Evidently manufacturers and their design engineers, accustomed to working with metals, must replace them with non-metallic materials wherever possible.

The substitution problem confronts manufacturers now and urgently, especially makers of civilian goods, if they want to be in a position to make and deliver goods 3 months hence. The engineering problem presented is sometimes simple, but often involves complete new designs for parts and retooling of shops. The Table provides a list of examples of successful substitutions in the realm of peace-time product design that have reached the quantity-production stage. FPP (3)

Successful Substitutions in Design

Type of Product	Former Material	Substitute Material	Cost After Change
REFRIGERATOR			
Ice Cube Trays	aluminum	tinned copper; steel	higher
Door Handles	zinc die casting	injection plastic	same
Interior Fronts	aluminum stamping	steel, cadmium plate	same
Trim on Humidifier	aluminum	plastic	lower
Thermo Housing	aluminum	stainless steel; plastic	lower
Evaporator	stainless steel	tinned copper; enamel on steel	higher
Hydrator	enameled steel	pliofilm zipper envelope	....
RANGES AND HEATERS			
Gas Burner Head	aluminum die casting	cast iron	lower
Vent Grill	aluminum casting	steel stamping	lower
Kerosene Tank	zinc	glass	....
Range and Heater Trim	chromium or nickel steel	plastic	....
OTHER HOUSEHOLD EQUIPMENT			
Cooking Utensils	aluminum	enamel on steel	higher
Kitchen Cabinets	steel	wood	....
Dinette Table Tops	steel	laminated wood	....
Cutlery	nickel silver	discontinued	....
Fly Screens	bronze	plastic	....
Washing Machine Agitator	aluminum	bakelite	lower
Washing Machine Clutch Handle	zinc die casting	bakelite	....
Vacuum Cleaner Dome	aluminum die casting	injection plastic	lower
SMALL TOOLS			
Lathe Face Plates	aluminum	cast iron	higher
Electric Tools—Handles	aluminum	plastic	lower
Saw Guard	zinc die casting	plastic	....
FARM EQUIPMENT			
Wire and Fence	galvanized steel	"Corronized" steel	....
CONSTRUCTION			
Rigid Electrical Conduit	galvanized steel	black-enamel on steel	....
AUTOMOBILE BODY PARTS	steel	soy bean fiber laminated plastic	....
SPORTS			
Boat Whistle	chromium plated brass	plastic	lower
Skeet Trap	aluminum casting	cast iron	lower
Ski Pole Rings	aluminum rod	rattan	same
Camera Case	aluminum casting	plastic	lower
Film Spool	aluminum	plastic	lower
Thermos Bottle Top	aluminum	plastic	same
Bicycle Frame	steel	laminated plastic plywood	....

3a. Ferrous

Welding-Fittings

"Steels for Welding Fittings." J. J. Kanter (Crane Co.) *Heating, Piping & Air Conditioning,* Vol. 13, Apr. 1941, pp. 213-216; May 1941, pp. 288-290. Survey report.

The steels from which welding-fittings are manufactured are purchased under a number of A. S. T. M. specifications covering different steel products and forms, and various carbon and alloy grades. Specific product requirements for welding-fittings as to metallurgy, inspection and identification are not to be found in these specifications.

A new A. S. T. M. tentative specification (A234-40 T) specifically for welding-fittings has been prepared to cover the quality of materials in wrought fittings. The term "welding fittings" as used in the new specification applies to butt-welding or socket end parts such as 45° and 90° elbows, 180° return bends, caps, reducers, lapped joint stub ends and other types.

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Aristoloy "Special Quality" Electric Furnace Steels include Tool Steels, Stainless Steels, Oxidation and Corrosion Resisting Steels, Aircraft Quality Steels, Valve Steels, Special Steels, etc.

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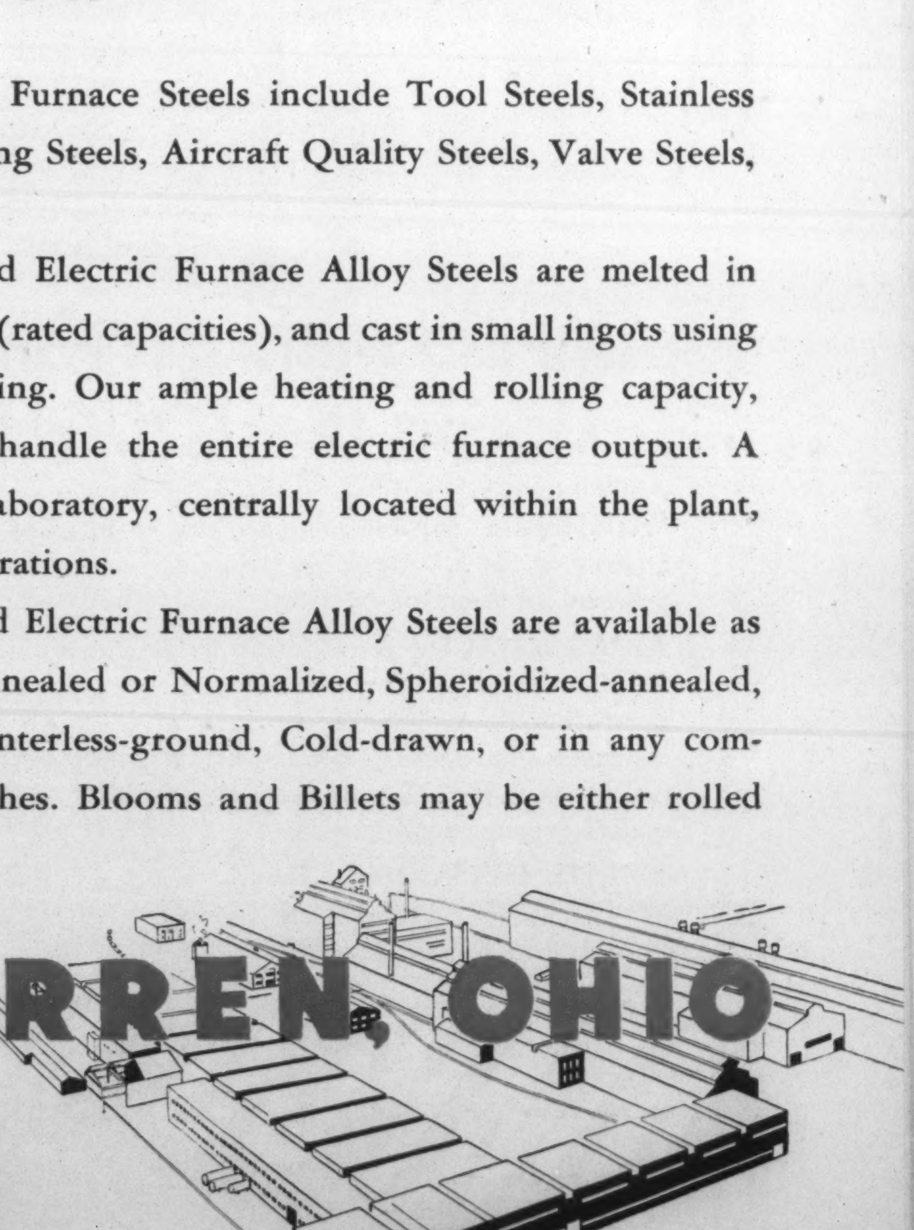

SPECIAL QUALITY BILLETS AND BARS, OXIDATION AND CORROSION RESISTING STEELS, TOOL AND SPECIAL STEELS, AIRCRAFT QUALITY STEELS, STAINLESS STEELS

The basic materials used may be either pipe, tubes, plate, strip, blooms, billets, slabs, bars, etc. and the manufacturing method employed may involve forging or shaping by hammering, pressing, piercing, rolling, extruding, upsetting, forge-welding, fusion-welding, etc. The specification covers any fitting (except cast fittings, which are the subject of other specifications) regardless of method of manufacture, that fulfills the standard requirements as to suitability and quality.

The compositions for plain carbon and carbon-molybdenum steels set forth as suitable are all recognized as weldable grades. Only those raw-material-manufacturing factors pertinent to the ultimate service as fittings are specified—among other things, whether made in the open hearth or electric furnace, and, for high-temperature service, the use of silicon-killed steel.

The heat treatment given factory-made welding-fittings depends on the forming procedure and the grade of steel. With hot-finishing by bending or forging within the 1150°-1650° F. range no further treatment is necessary, for cooling from this range leaves the steel in a satisfactorily stress-relieved condition.

Finishing from *above* 1650° F., however, may leave the steel in a grain-coarsened state with low toughness, and such finishing should be followed by normalizing. Likewise, finish-forming operations conducted *below* 1150° F. must be followed by stress-relieving to give a fitting fully as reliable as a hot-formed unit.

Carbon-molybdenum steels, whether hot or cold finished, must be heat-treated according to A. S. T. M. prescriptions for the type of material from which the fittings are fabricated. Tentative use of the new specification may show that these specific requirements for fittings made from plate, pipe, billets or bars may need amplification.

Tension tests of finished fittings are not required, but fittings must stand a hydrostatic pressure test. If a tensile test is considered desirable as an indication of general quality, it must be made on specimens cut from fittings rather than on the unprocessed raw material from which the fittings were made.

Marking requirements are a difficult problem and may have to be subsequently clarified. Where steel stamps are used, care should be taken that the marking is not deep enough to cause cracks or to reduce the wall thickness of the fitting below the minimum allowed. (3a)

Stainless Steel in Aircraft

"Stainless Steel in Aircraft." Research Staff (Allegheny-Ludlum Steel Corp.) *Iron Age,* Vol. 147, Jan. 30, 1941, pp. 35-40. Survey.

Stainless steel has been used only to a limited extent in structural aircraft members that have to carry stresses. Aluminum alloys are used almost exclusively for this purpose. This preference for other metals is caused by a lack of proper facilities such as dies and presses for forming stainless steel, and a lack of knowledge of the properties of stainless steels.

Relatively little has been said about the mechanical properties of stainless steels in spite of the variety of remarkable properties that can actually be obtained. [*See, for example, the editorial "18:8 and Notched Fatigue" in the Dec., 1940* Metals and Alloys, *p. 733.*] The major characteristics to be considered in connection with metal to be used in the aircraft industry are: strength/weight ratio, forming properties, and weldability.

Stainless vs. Duralumin

Stainless is often considered at a disadvantage because thin sections would be employed to match the strength and weight of an aluminum design. The density of duralumin is about 2.8 while that of 18/8 stainless is about 7.95. The best mechanical strength obtained with aluminum alloys are a tensile strength of about 62,000 lbs./in.^{2} and yield strength of about 42,000 lbs./in.^{2} Thus, a given volume of stainless steel is 2.83 times as heavy as aluminum alloy, and in order to have as good a strength/weight ratio, stainless must have a yield strength of at least 119,000 lbs./in.^{2} and tensile strength of at least 175,460 lbs./in.^{2}

If 1 in. section of stainless steel is equivalent to 2.83 in.^{2} of duralumin, and if the modulus of elasticity of duralumin is about 10,300,000 lbs./in.^{2} and of stainless steel about 27,000,000 lbs./in.^{2}, then a bar of duralumin would deflect 0.00607 in./in. at "yield strength" of 119,000 lbs. total load on a 2.83 in.^{2} cross-section, while stainless steel would deflect about the same at yield strength of 119,000 lbs. on a 1 in.^{2} cross-section. Therefore, it would not be advisable to change from aluminum to stainless for aircraft parts that have to carry stress, because to maintain the same strength-weight ratio the thickness of a stainless steel part would have to have approximately 1/3 the thickness that it had when made from aluminum.

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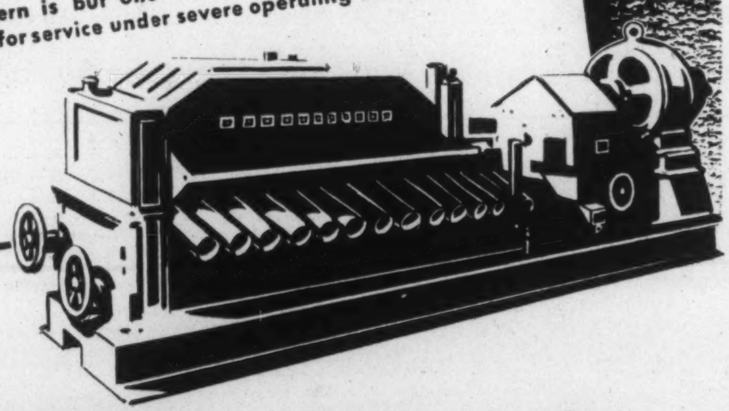

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However, this is true only if parts designed for aluminum alloys are made out of stainless steel without any redesigning to take into account the properties of stainless steel. With a flat piece of duralumin and a flat piece of stainless each having the same length but differing in cross-section so as to have the same strength and weight, the duralumin would have greater resistance to buckling because of its greater cross-section area. This advantage could be easily overcome by corrugating flat stainless steel.

Cold-rolled stainless, with an elongation of about 15% in the 2-in. gage length of standard tensile test, should be ductile enough to make the bends used for structural members. With 0.11% C and about 19% Cr and 9% Ni, by proper cold rolling, stainless strip with 15% elongation has a yield strength of 129,000 lbs./in.^{2} and a tensile strength of 145,000 lbs./in.^{2} With 0.10% C and about 18% Cr and 8% Ni, the yield strength becomes 140,000 lbs./in.^{2} and the tensile strength 160,000 lbs./in.^{2} These compositions—the most likely for type 302—are not good enough to compete with aluminum. In addition, most of the 17-7 type 301 steels will give very similar results to the 18-8 type.

However, if the composition is controlled to give between 7.0-7.2% Ni, 17-18 Cr and 0.13-0.15 C with close to 0.05 Mn, cold-rolled strips and sheets can be had with yield strength of 170,000 lbs./in.,^{2} tensile strength of 200,000 lbs./in.^{2} and elongation of 15%. This gives a tensile strength 15% greater and yield strength 42% greater than those of duralumin. If the chromium of the above composition is held close to 18%, then alloys having the same desirable properties can be produced that contain 0.10-0.12% C. This carbon content is desirable to facilitate solution of carbides during annealing.

Mechanical Properties

Allegheny-Ludlum experiments show the compositions of 0.09-0.13% C, 0.50-0.70 Mn, 18-19 Cr and 6.25-7.0 Ni have high mechanical properties after cold rolling. In alloys with about 5.5-7.5% Ni and 17-21 Cr, increasing chromium produces an alloy with a more stable austenite when judged on the basis of work hardening and mechanical properties. In order to obtain high tensile stainless steel with the best mechanical properties and have a sufficiently broad range of chemical compositions so it can be made on a commercial basis it is necessary to have a minimum nickel content of 7%.

In order to specify desired properties, the old classification of "tempers" must be replaced by a new one that coordinates the various tempers with yield strengths and allows tensile strengths to fall where they may, or a different relationship between temper, yield strength, and tensile will have to be used for compositions showing different rates of work hardening. In the annealed condition, all austenitic chromium-nickel steels with the same carbon content have about the same yield strength; this is true for 18.5% Cr, 6.8% Ni analysis, as well as for regular 19-9 composition. However, beyond the elastic range various rates of work-hardening of different compositions influence the stress at which breaking occurs. Compositions with the greatest work-hardening rate show higher breaking strengths.

Mechanical properties of strip to be used as load bearing members are obtained through cold rolling. Therefore, attention is given to variations in properties in different directions resulting from rolling. Variations differ with different lots, depending primarily on processing conditions.

Tests were conducted in tension and compression in both longitudinal and transverse directions on a low-nickel composition (0.12% C, 0.47 Mn, 18.01 Cr and 6.96 Ni). Strip was rolled to a thickness of 0.27 in. and stress relieved. In tension, the longitudinal yield strength was 174,800 lbs./in.^{2}, tensile strength 199,200 lbs./in.^{2}, and % elongation 16.0, and the compression yield strength was 169,800 lbs./in.^{2} In transverse tension the yield strength was 184,300 lbs./in.^{2}, tensile strength 203,000 lbs./in.^{2}, and % elongation 13.0. Compression yield strength was 199,000 lbs./in.^{2} A composition containing less than 7% Ni has no particular advantage at low hardnesses. VSP (3a)

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Prevention of Rail Failures

"Seventh Progress Report of the Investigation of Fissures in Railroad Rails." *Am. Railway Eng. Assoc., Bulletin* 423, Dec. 31, 1940, 79 pp. Also to appear as *Univ. Ill. Eng. Expt. Sta.* Reprint No. 21.

This is a general summary of the work on rails at the University of Illinois under Professor H. F. Moore, giving in one place the boiled-down results of many years' work, much of which has previously been reported piece-meal.

Among the important conclusions are that the endurance limit of non-shatter-cracked rail steel is 55,000-65,000 lbs./in.^{2};

and of rail steel with small cracks present, 25,000-30,000. In a rail wheel with shatter cracks loads of 40,000 lbs./in.^{2} (present in normal operation) will start a crack; loads of 30,000 lbs./in.^{2} will make it propagate, so it is likely that a shatter-cracked rail will develop transverse fissures within the life expectancy that would be set from other causes.

The primary cause of shatter-cracks appears to be hydrogen in the steel and, short of finding some sure way of preventing the entrance of hydrogen in, or of removing it from the melt, the logical way to avoid shatter-cracks is to allow time for escape of hydrogen from the rail before it has cooled to the temperature at which shatter-cracks form. This temperature is below 300° F., but if cooling from at least 700° F. to 300° F. takes 7 hrs. or longer, or if a rail to be normalized by the Brunorizing process is held at least 2 hrs. at 1000° F. before reheating from that temperature to the normalizing temperature, ample opportunity is given for hydrogen to escape, and even rails from steel intentionally charged with hydrogen, do not show shatter-cracks.

In rails that have not been given such treatment, shatter-cracking is facilitated by the presence of segregated areas. High in carbon, manganese and phosphorus, these are also likely to contain inclusions or slag streaks. Split heads, and sometimes transverse fissures, can result from slag streaks, even in properly cooled rails.

The static strength of rail steel increases, and ductility is lowered, as the temperature drops. The endurance limit, either of notched or unnotched bars, rises (or at least does not fall) as the temperature drops from room temperature to —50° F. Impact resistance, either notched or unnotched, does fall.

End hardening of rails to prevent end-batter, as carried out by several methods, improves the tensile strength, ductility, endurance limit and impact resistance, by producing a better metallographic structure, but the usable hardness is about 45 Rockwell C. At 50 Rockwell C. the toughness is greatly reduced. Work is still in progress on end-hardening and will be more completely reported later.

None of the non-destructive tests for shatter-cracks have been satisfactory. Bend testing has promise for replacing drop testing, and experiments are under way that may lead to a specification for bend testing. Recommended practices for controlled cooling and specifications for controlled-cooled rails are in process of preparation.

HWG (3a)

Chromium-Manganese Steels for High-Temperature Service

HEAT-RESISTING CHROMIUM-MANGANESE STEELS AS SUBSTITUTES FOR CHROMIUM-NICKEL STEELS ("Hitzebeständige Cr-Mn-Stähle als Austauschwerkstoff fur Cr-Ni-Stähle") M. SCHMIDT & W. LAMARCHE. *Korrosion u. Metallschutz*, Vol. 16, Dec. 1940, pp. 425-427. Review plus research.

Recent investigation and a survey of the literature show that, in general, the oxidation-resisting chromium-nickel steels can be replaced for temperatures up to 1750° F. by chromium-manganese (and chromium-manganese-nitrogen) steels, and also by chromium-manganese-silicon steels.

Chromium-manganese steels are also claimed to be capable of higher loading and to have a higher resistance to oxidizing sulphur-containing gases. They should not, however, be used in reducing atmospheres as they are sensitive to carburizing gases.

A typical heat-resisting chromium-manganese steel has 0.10% C, less than 0.50% Si, more than 15% Mn, less than 15% Cr, with additions of titanium, tantalum and columbium; its properties are 50,000-63,000 lbs./in.^{2} elastic limit; 85,000-100,000 lbs./in.^{2} ultimate strength, 40% elongation, and notch-impact strength of 25 m-kg./cm.^{2}

The chromium-manganese-nitrogen steel (0.10% C, less than 0.50% Si, more than 15% Mn, less than 15% Cr, and 0.25% N) has 65,000-85,000 lbs./in.^{2} elastic limit, 100,000-130,000 lbs./in.^{2} ultimate strength, 40% elongation, 25 m.-kg./cm.^{2} notch-impact strength.

The composition of the chromium-manganese-silicon steel is 0.10% C, 3.5% Si, more than 16.5% Mn, less than 10% Cr, with additions of titanium, tantalum and columbium. Its properties are 50,000-63,000 lbs./in.^{2} elastic limit, 100,000-120,000 lbs./in.^{2} ultimate strength, elongation 35% and 18 m.-kg./cm.^{2} notch-impact strength.

"Creep test" results indicated the chromium-manganese-nitrogen and the chromium-manganese steels to be better at 1100°, 1200°, 1300° and 1400° F. than chromium-nickel steels of the 25/20 and 20/14 types. The chromium-manganese-silicon steel showed creep strength at 1100° and 1300° F. equal to the chromium-manganese steel but lower than the Cr-Mn-N steel.

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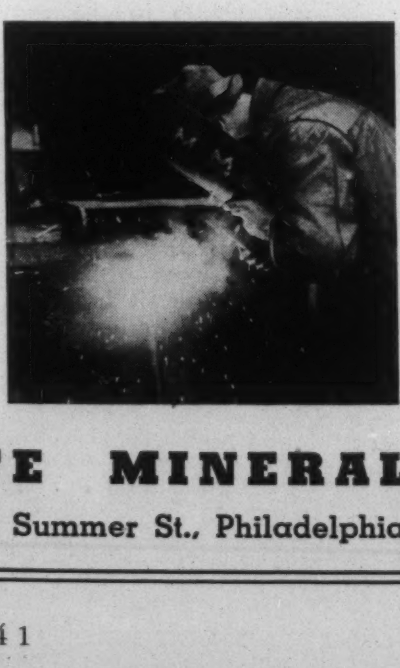

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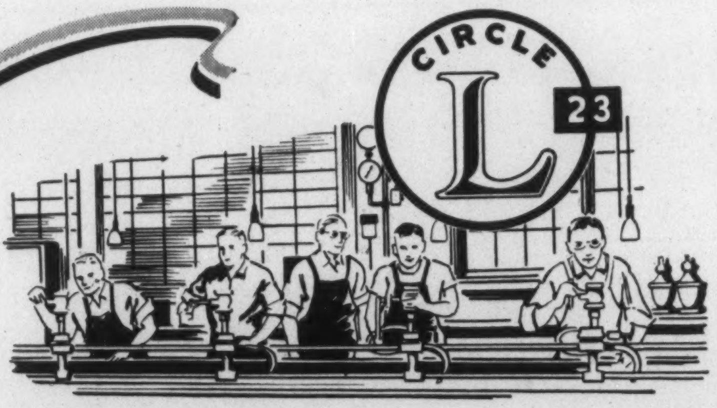
FEW American military emblems have a prouder battle history than the "YD" worn on the shoulders of New England's National Guardsmen. As the 26th, or "Yankee" Division, the New Englanders were one of the first Guard outfits to see action in World War I. In the great struggle of the Aisne-Marne, they were in line for fifteen days and lost more than 5,000 men. It was the aggressive "Yankees" who finally captured Belleau and held it in the face of a heavy three day artillery fire. In the Saint Mihiel operation they were active and in the Meuse-Argonne their deeds made Ville-devant-Chaumont an heroic name. During a service of 205 days in the front line, their casualties totalled 13,664 men. Today, the New England National Guard is in camp, preparing again to stand watch over American liberties.



INDUSTRY, TOO, must stand watch—with alert eyes on the foes of production. Foremost among these is corrosion. Among the corrosion resistant alloys developed by the Lebanon Steel Foundry, Circle L 23 is widely accepted because of its generally good corrosion resistant qualities combined with satisfactory physical characteristics. At Lebanon, this alloy is induction furnace melted. It and the other Lebanon alloys have made possible changes in methods and practice of far reaching economic value.

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ORIGINAL AMERICAN LICENSEE GEORGE FISCHER (SWISS CHAMOTTE) METHOD

LEBANON *Stainless and Special Alloy* STEEL CASTINGS

[*Chromium-manganese steels with chromium content less than 15% would be expected to scale appreciably at temperatures above about 1500° F. Since addition of 3.5% Si requires chromium less than 10% to keep the steel austenitic, no improvement in scaling resistance would be expected. The details of the creep tests are not given but since Schmidt has previously quoted tests for very short times, the data given above are of doubtful value.* H. C. C.]

Ha (3a)

3b. Non-Ferrous

Auto-Bearing Lubrication

"CRANKCASE OILS FOR HEAVY-DUTY SERVICE." H. R. WOLF (Gen. Motors Corp.) *S. A. E. Journal*, Vol. 48, Apr. 1941, Trans. pp. 128-137. Investigation.

Failures of copper-lead bearings are discussed. Such failures may be classified as loss of lead due to corrosion by lubricant and mechanical failure due to fatigue. As corrosion and fatigue are greatly accelerated by increase in bearing pressure, tests made in full-size multi-cylinder engines more closely approximate service conditions than do miniature single-cylinder engine or laboratory bearing-corrosion tests.

Lead loss may be caused by solvent action of the acidic products formed on oxidation of the base oil, which may be greatly accelerated by the catalytic effect of metallic soaps used as detergents. Lead loss may also be caused by the action of these metallic soaps under pressure in the heavily-loaded bearing areas. This is a relatively new phase of the problem.

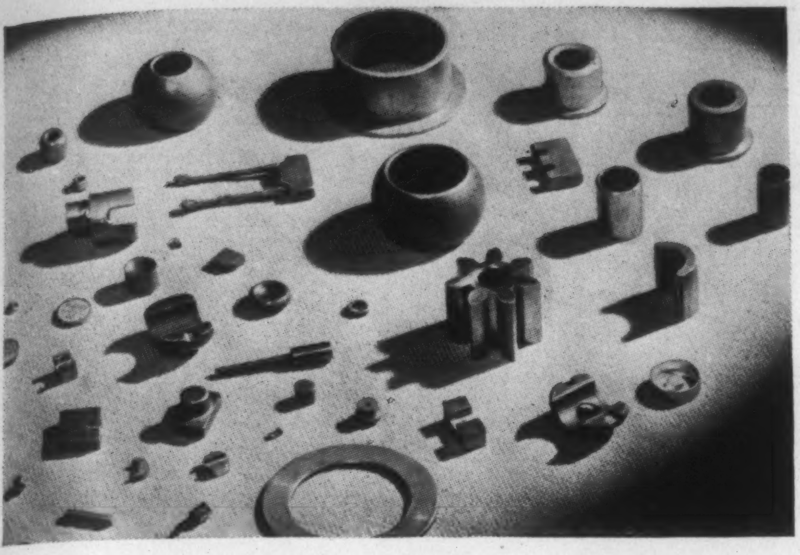
Actually, tests show that corrosion can be due entirely to the action of the particular metallic soap used in the lubricant. Tests made with other lubricants, inhibited with similar anti-oxidants but without metallic soap, showed no loss in lead from the bearing surface.

Metallic soaps appear to decompose under the conditions existing in high-pressure areas of heavily loaded bearings, yielding free acids, which attack the lead in copper-lead bearings in the same manner as the acidic products formed on oxidation of the base oil. Metallic detergent compounds other than metallic soaps, which either do not decompose under the conditions existing in high-pressure bearing areas or do not form free acids or acidic compounds on decomposition, do not cause bearing corrosion.

Fatigue failures can be distinguished readily from failures due to lead loss. In fatigue failures, the lead in the copper-lead structure extends to the surface of the fatigue crack. A recent development in corrosion-resistant bearings—with possibly good fatigue properties—is the 1941 Buick main crankshaft bearing, which is similar in structure to the conventional copper-lead bearing.

This new type of bearing [*described in* METALS AND ALLOYS *for October 1940, p. 471*] has a hard strong matrix filled with a high-lead corrosion-resistant babbitt. If the matrix is completely covered with a thin layer of babbitt, the bearing may be considered as a very thin babbitt bearing having all the frictional properties of babbitt and many of the structural properties of copper-lead bearing. For extremely heavy-duty service where higher fatigue properties are desired, the hard matrix may be exposed on the bearing surface by having a thinner babbitt layer.

This type of bearing is being tested under heavy-duty operating conditions. If these service tests indicate that it is satisfactory in fatigue resistance and bearing properties, and if it can be produced commercially, it will solve the bearing corro-



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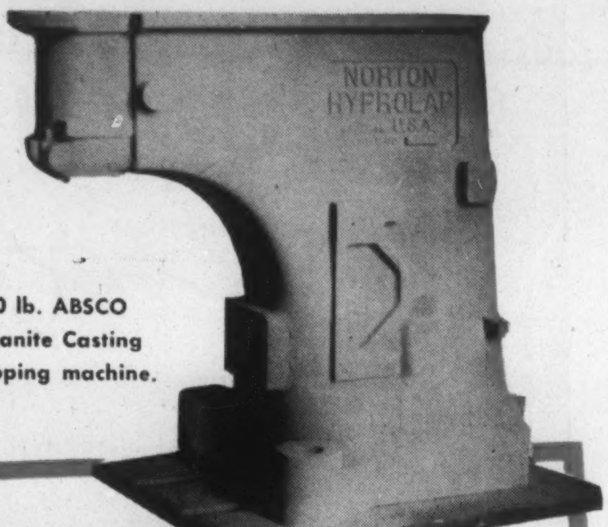

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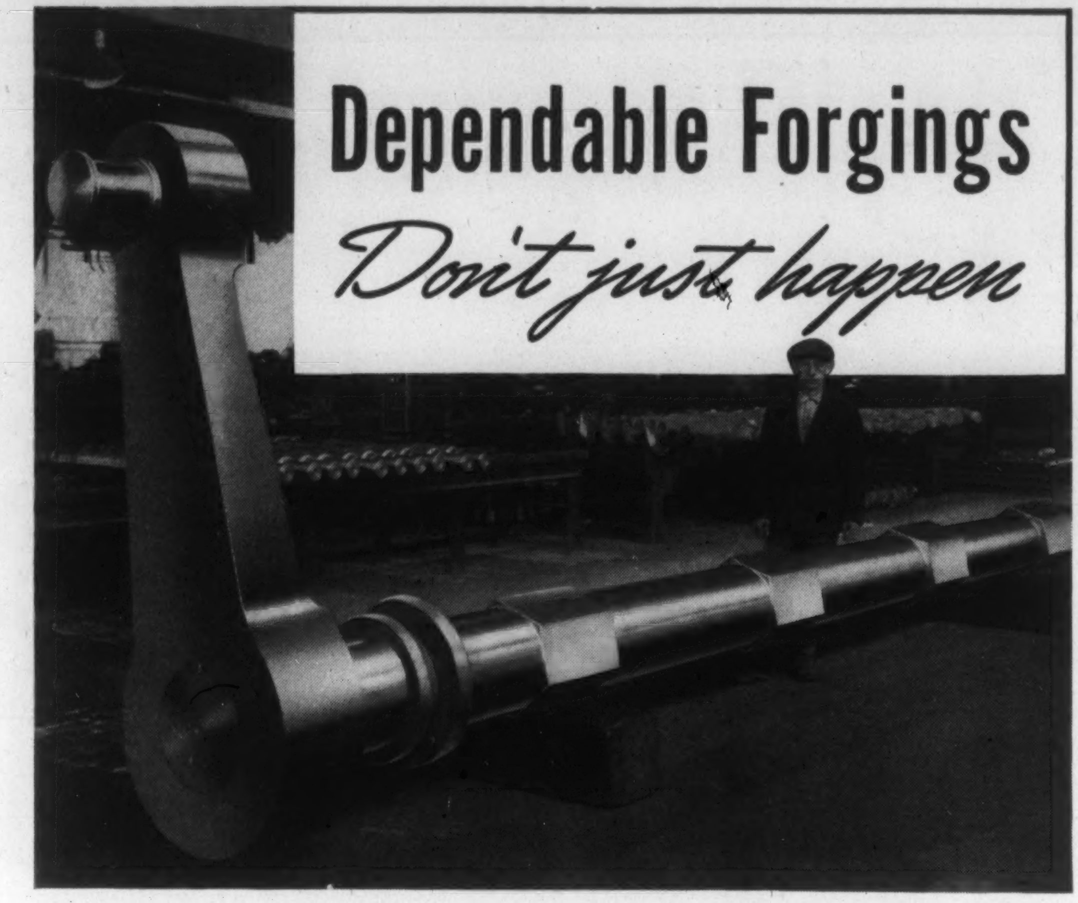

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sion problem. However, the petroleum industry will still have to supply crankcase oils that do not oxidize in service.

Further development of heavy-duty lubricants containing suitable inhibitors and detergents, remains as the only permanent and satisfactory solution of the problem.
MS (3b)

Corrosion of Clad-Aluminum

A Composite

Some new data on the corrosion of structures composed of strong aluminum alloy "clad" with corrosion-resistant pure aluminum have appeared in German publications. In one case the important effect of fatigue cracks on corrosion resistance is stressed, and in the other a suggestion is made for improving the inherent corrosion resistance of the pure aluminum cladding.

Fatigue Cracks and Corrosion

Clad aluminum-copper-magnesium alloy sheet displays very interesting fatigue behavior, report H. Burnheim & R. Mechel ("Rissbeobachtung an der Oberfläche wechselbiegebeanspruchter, plattierter Bleche aus Aluminum - Kupfer - Magnesium-Legierungen," *Z. Metallkunde*, Vol. 33, Jan. 1941, pp. 25-27). Such clad sheet tested in 2 fatigue bending machines assumed a rough surface sometimes similar in appearance to the effect of sand-blasting. The defect was most pronounced in the center of the test pieces and gradually disappeared toward the clamped ends.

Microscopic tests revealed the development of cracks in great number (but not very deep) at alternating bending stresses approaching the yield point of the sheets. At lower loads, only a small number of cracks appeared, but these penetrated deeply into the material and sometimes extended even into the base metal. Even at extremely small loads, which led to fatigue failure after a very high number of cycles, isolated cracks appear, all of which penetrate into the base metal.

The relatively low strength of the cladding material (pure aluminum) in comparison with the base metal is considered to be the cause of failure. This failure has important implications, since the corrosion protection of the cladding may be lost at an early stage in the event of continuous cycles of bending stresses.

The authors believe that corrosion damage observed on clad aluminum-copper-magnesium alloys in the aviation industry is partly attributable to the formation of the above cracks, which cannot be readily detected under the protective lacquer coating or even on the uncoated sheet.

Calcium-Bearing Cladding

The efficacy of small calcium contents in improving the corrosion resistance of aluminum cladding on aluminum-copper-magnesium alloys is discussed by W. Bungardt ("Korrosionsschutz von Aluminium-Kupfer - Magnesium - Legierungen durch Plattierschichten aus kalziumhaltigem Aluminium," *Z. Metallkunde*, Vol. 32, Nov. 1940, pp. 363-368). An earlier U. S. Patent (No. 1,997,165) had called attention to the beneficial effect of calcium in aluminum used for cladding. The author studied such material by tensile, microscopic and corrosion tests.

The aluminum-copper-magnesium alloy sheets were protected on both sides by pure aluminum containing 0.55% Ca (5% of the total thickness). Although aluminum has been reported by Nowotny *et al* [see Metals and Alloys, Vol. 11, June 1940,

p. MA 354] to dissolve 2.75% and 1.7% Ca, respectively, at 1140° F. and 572° F., the author's micros show a heterogeneous stucture of the outside layers of calcium-bearing aluminum. This is attributed to the formation of Ca_2Si (74% Ca) through silican-contamination. Tensile tests show the calcium-bearing aluminum to be only slightly weaker than the same alloy clad with pure aluminum.

Samples were solution-annealed for 15 min. at 930° F. and age-hardened at room temperature once, 4, 12 and 20 times, and then examined microscopically. The diffusion of the copper-atoms into the outside layers was considerably retarded by the presence of calcium. As the corrosion resistance of aluminum-clad material drops on long-time annealing because of the copper-diffusion, this retarding effect of calcium is beneficial.

Corrosion tests in 3% sodium chloride + 0.1% hydrogen peroxide actually showed an improvement with increasing annealing times at 930° F. This latter effect is attributed to the formation of protective surface layers, probably of $Ca(OH)_2$.

EF (3b)

Creep Properties of Brass

"Time and Temperature Effects in the Deformation of Brass Crystals." H. L. Burghoff & C. H. Mathewson (Chase Brass & Copper Co. & Yale U.) *Metals Tech.*, Vol. 8, Feb. 1941, 11 pp. Research.

As tested by the usual tensile-testing procedure at room temperature, single crystals of 71-29 brass show a small but definite drop in load as plastic deformation first begins, indicating the existence of a yield point as in iron crystals.

The critical maximum resolved shear stress in slow tensile tests ranged from about 1850 to 2085 lbs./in.^{2} at room temperature and was not substantially changed at 300°, 500° and 700° F. The yielding or first plastic deformation in such tests became more abrupt and the rate of yielding became more rapid as the test temperature was increased.

Creep tests revealed the existence of a true elastic limit or creep limit—at least within the sensitivity of the tests—below which no plastic deformation was observed throughout periods as high as several hundred hours. This limit corresponded to a maximum resolved shear stress of about 1425 to 1565 lbs./in.^{2} and was substantially unchanged from room temperature to 500° F. At 700° F. appreciable creep occurred for resolved stresses as low as 285 lbs./in.^{2}, and it seemed probable that creep would take place at any stress at this or higher temperature.

The initial plastic deformation in the creep tests at all temperatures took place at an increasing rate, the rate later decreasing and, for the lower temperatures, apparently approaching zero. Evidence was found that the amount of creep was directly proportional to the number of slip bands defining planes that must have operated either simultaneously or in succession during the process.

JLG (3b)

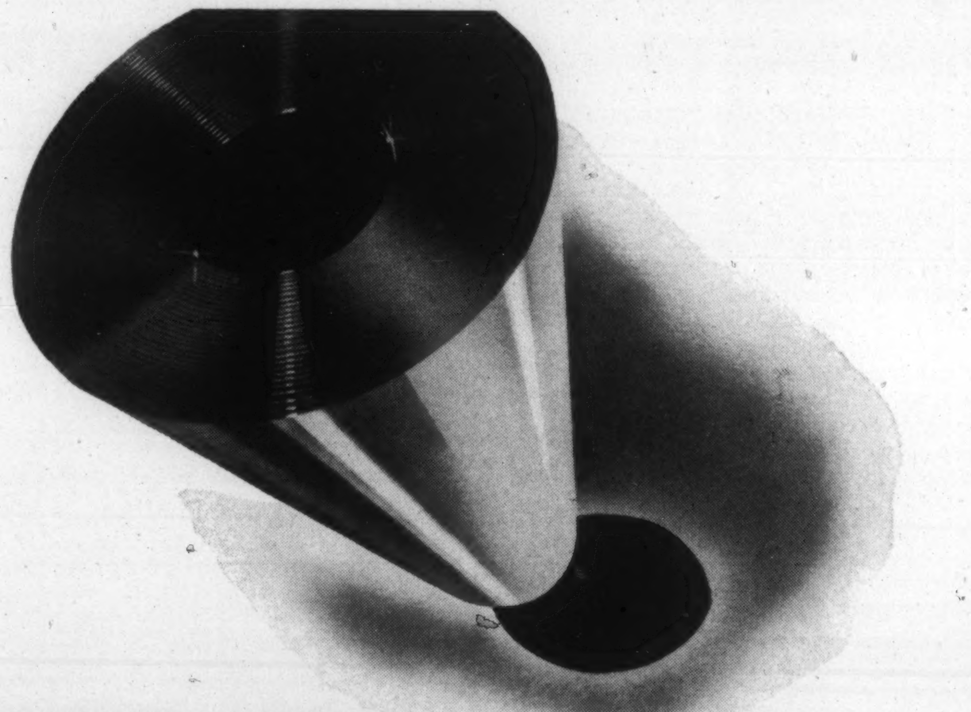
Aluminum in Shipbuilding

"The Marine Use of Aluminum." A. C. Hardy. *Sheet Metal Inds.*, Vol. 15, Feb. 1941, pp. 197-201. Descriptive review.

The shipbuilding industry is extremely conservative and reluctant to adopt new materials until they have been proven beyond doubt. One advantage of aluminum often mentioned is a possible reduction in upkeep by virtue of its increased resistance to corrosion. This point is questionable, although alloying additions and better paints have undoubtedly improved corrosion resistance. However, the use of aluminum in the interior of tankers should offer advantages, since aluminum is resistant to both seawater and petroleum products. Welded aluminum would eliminate the difficulty with corrosion at rivets; sprayed aluminum also offers advantages.

Another advantage frequently cited for aluminum is the increased earning capasity and speed of ships employing it, owing to the light weight of the metal. This factor would be of most interest to warships, and fast passenger ships, particularly if aluminum were used for hulls, but aluminum has never been used on a large scale for this purpose, although small experimental ships with aluminum have been immersed for months with no deleterious effects. Less revolutionary is the use of aluminum for superstructures, although this too requires a change in design and methods of working. Increased use of welding in shipyards will make this change-over less radical.

The most extensive use of aluminum at the moment is in the *Fernplant*, a cargo liner built by Burmeister and Wain for a Norwegian owner shortly before the invasion of Denmark. The upper deckhouses, the captain's house and chartrooms were made of an aluminum alloy resistant to seawater (analysis not given), while portholes and windows were made of cast aluminum. For the first time welded sheet aluminum was used in a major seagoing shipbuilding structure. The strength of work-hardened



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and heat-treated alloys may be advantageous, although the designer must take into account the lower modulus of elasticity of aluminum as compared with steel.

The abolition of fire hazard by the use of aluminum in partitions in quarters would be particularly important in passenger liners. There might also be an improvement in navigation conditions through the use of a non-magnetic material which would not affect the compass. Aluminum does have a future in shipbuilding if these advantages can be obtained at a reasonable price, and if builders, workers, and standards societies can be convinced of them. JZB (3b)

Conductivity of Copper Alloys

"Effects of Cold-work upon Electrical Conductivity of Copper Alloys." D. K. Crampton, H. L. Burghoff & J. T. Stacy (Chase Brass & Copper Co.) *Metals Tech.*, Vol. 8, Feb. 1941, 14 pp. Investigation.

The effect of cold work upon the electrical conductivity of several types of copper and of numerous copper alloys was determined for reductions of area by drawing up to about 84%. The lowering of conductivity of copper by such working was found to be less than 4%. Slight differences were found between the different coppers, and these may be attributed to the presence or absence of oxygen, silver or phosphorus.

For copper alloys of the solid solution type the results ranged from changes comparable with those for copper to far greater changes, according to composition and degree of working. In general, it was found that the lowering of conductivity increased with the alloy content and with degree of draw. Very marked changes occurred in copper-zinc and copper-aluminum alloys.

In the alpha range of copper-zinc alloys, the effect of cold working increased greatly for alloys containing more than 10% Zn, reaching a maximum in the range of 25-35% Zn, depending on the degree of working, and thereafter decreasing. In the alpha + beta range of copper-zinc alloys, the lowering of conductivity by working was also great and became more pronounced as the proportion of beta increased.

The conductivity of several age-hardening alloys in the quenched condition was found to be increased by some degrees of drawing, apparently because of precipitation from the supersaturated solution in drawing, although the normal lowering effect predominated for other degrees of drawing. Other alloys did not yield such variable results. In the age-hardened state, the decrease in conductivity was roughly proportional to the degree of draw.

JLG (3b)

Corrosion of Magnesium Alloys

Effect of Contaminations on the Corrosion Characteristics of Magnesium and Its Alloys with Manganese and Aluminum ("Ueber den Einfluss von Verunreinigungen auf die Korrosionseigenschaften des Magnesiums und seiner Legierungen mit Mangan und Aluminium"). Alexander Beerwald. *Z. Metallkunde*, Vol. 33, Jan. 1941, pp. 28-31. Original research.

Re-distilled pure magnesium (analysis given) was tested in 0.3% NaCl solution and the hydrogen evolved taken as a measure of the corrosion attack. (Tests in tap water or with commercial alloys yielded poor reproducibility.)

Iron contaminations as low as 0.005% and smaller resulted in a drastic increase in corrosion. Magnesium free from iron shows markedly increased corrosion resistance over "commercially pure" magnesium. At iron concentrations higher than 0.02%, the corrosion rate remains constant. The author concludes that magnesium dissolves chlorine, but could not definitely prove a harmful effect on the corrosion stability.

A series of magnesium-manganese alloys containing between 0.2% and 3.7% Mn and of magnesium-manganese-iron alloys containing a constant iron content of 0.008% and between 0.14% and 1.14% Mn showed that manganese markedly improves the corrosion resistance of magnesium and even immunizes the presence of 0.008% Fe. Magnesium-manganese alloys containing even less than the commercial concentration of 1.8% Mn are sufficiently stable; higher manganese additions offer no advantage in regard to corrosion resistance. The counteracting effect of manganese with respect to iron means that high-purity magnesium need not be used for manganese-magnesium alloys.

As to the effect of iron on magnesium-aluminum alloys (4% and 8% Al) with and without 0.25% Mn, it was found that the use of aluminum additions of 99.997% purity yielded alloys superior to those made with ordinary commercial aluminum. The addition of 0.25% Mn resulted in increased corrosion resistance. The corrosion attack of the 8%-Al magnesium alloy was higher than that of the 4%-Al alloy, all other conditions being the same.

FF (3b)

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New Electron Microscope

"New Electron Microscope." *J. Applied Physics,* Vol. 12, Mar., 1941, p. 187. Descriptive.

Details of a more effective and simplified model of the RCA electron microscope were discussed recently before a convention of the Institute of Radio Engineers by James Hillier of the RCA Research Laboratories.

The electron microscope is capable of magnifying objects up to 100,000 times. RCA's first electron microscope, announced early last year, was designed primarily for use by electrical experts and physicists; the new model is smaller and better adapted for use in general laboratories, since it may be operated by any competent laboratory worker.

The new instrument, housed in a steel cabinet, is completely self-contained and is ready for operation when plugged into an ordinary light socket. It is not affected by magnetic fields set up by other electrical equipment, as was the earlier model, nor is it disturbed by ordinary room vibrations.

An important feature is an ingenious "submarine lock" arrangement for changing specimens in the evacuated chamber of the instrument without admitting air. A number of viewing windows are provided through which several persons can study specimens at the same time.

The RCA electron microscope operates very much like an ordinary light micro-

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scope, except that instead of glass lenses and light, it utilizes a stream of electrons propelled at high speed through a series of magnetic coils. The new microscope is now being produced for use in leading educational and commercial research laboratories throughout the country.

HFK (4)

Hot-Strength of Molding Sand

"TEST HOT STRENGTH OF MOLDING SAND." N. J. DUNBECK (Eastern Clay Products Co.) *Foundry*, Vol. 69, Feb. 1941, pp. 39-40, 108. Practical.

The A. F. A. dry-strength test measures the strength of sand after baking for a definite period at 220° F. If cutting or washing is observed with low dry-strength, the dry-strength can be increased until the cutting stops, and the dry-strength can be kept at or above the increased figure.

Such correction will be successful on only that particular sand, for the reason that no relation exists between the dry- and hot-strengths of dissimilar sands and bonding clays. Casting results cannot be predicted from the present dry-strength test, and little information is available on hot-strength, although the A. F. A. sand research committee is currently studying this problem.

Preliminary tests were run on bond, combinations of clays, and binders. Samples were tested for strength in the furnace at various temperatures; for convenience only the hot-strength at 2000° F. will be discussed. The base sand was Michigan City, average grain fineness J3.

A 10% fire clay mixture when tempered with 3.3% water has a hot-strength of 295 lbs./in.[2] An increase in the clay content of 2%, to give a total of 12%, with 3.5% water increased the dry-strength 9.4% and the hot-strength 35.5%. When tempering-water for the 12% clay mixture is increased to 4%, both dry- and hot-strengths increased a further 37.5%.

Rapid increase in the hot-strength may account for cracked castings. Hot-strength tests on mixtures of Ohio fire clay and Western bentonite gave higher dry- and hot-strengths than either clay separately. Tests on mixtures of Western bentonite and Southern bentonite showed that dry- and hot-strengths increase with increased % of Western bentonite. Southern bentonite sometimes caused cuts and washes. Dry- and hot-strengths of Ohio fire clay and Southern bentonite are in relation to the quantities used, and desirable properties are possible.

With regard to binders, if 1% of corn flour is added to Southern bentonite, a great increase in dry-strength is noted, but in the hot-strength test the sand was highly collapsible. Addition of 1% corn flour to Western bentonite produced no increase in dry-strength and a great reduction in hot-strength. Both pitch and rosin give high dry-strength when added to Southern bentonite, but moderate hot-strength.

Dry-strength means nothing and casting behavior depends on hot-strength. Pitch often will stop washing before the gate although tests show that the strength it delivers does not persist to high temperatures. Neither dry- nor hot-strength should be used to predict casting results without further study to establish the hot-strengths required for particular weights and classes of castings.

VSP (4)

Eddy-Current Flaw-Inspection

"AN EDDY CURRENT METHOD OF FLAW DETECTION IN NON-MAGNETIC MATERIALS." R. GUNN. *J. Applied Mechanics*, Vol. 8, Mar. 1941, pp. A22-A26. Descriptive.

While the magnetic powder test is a very convenient and simple method for detection of surface or submerged flaws in magnetic materials, it is not applicable for non-magnetic metals. A new method applicable for such metals is described by which flaws and defects are detected by means of irregularities in eddy-current fields produced in the piece to be examined by alternating magnetic fields.

By first determining the eddy-current distribution in a perfect sample, deviations from this distribution in the test specimens indicate the defective places. This method lends itself very well to the non-magnetic-stainless steels. Examples and test curves are given and the practical application of the method is described in detail.

Ha (4)

Nuclear Physics in Inspection

"APPLIED NUCLEAR PHYSICS" (Section on Metallurgical Applications) ROBLEY D. EVANS (Mass. Inst. Tech.) *J. Applied Physics*, Vol. 12, Apr. 1941, pp. 263-264. Review.

The use of artificial radioactive substances in the study of diffusion processes promises to yield new information on basic metallurgical problems such as annealing, heat treating, powder metallurgy, corrosion

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in boiler tubes and reactions in forming blast furnace slags.

In radiographic inspection the new radioactive isotope radio-yttrium may find industrial use since it emits gamma rays that are almost homogeneous 2 million-volt rays and has a half-life of 100 days which is considerably greater than that of radon.

Compact high voltage X-ray generators used in nuclear research are beginning to find use in the inspection of thick steel sections. HFK (4)

X-Raying Welds

"An Inside Look at Welds." R. Baldwin. *American Machinist,* Vol. 85, Mar. 5, 1941, pp. 149-152. Practical description.

Calcium tungstate screens are used in front and back of the film to reduce exposure time. Filters (usually 0.005 in. lead) are also used in front and back of the film to cut down fogging. Gages of varying thickness are used as checks to prove that the radiograph has penetrated to the bottom of the weld. The A.S.M.E. power boiler code requires the final radiograph to show a gage slot with a depth of 2% of the total thickness of the weld.

At G. E. most of the radiographs are taken stereoscopically. The weld surface is smoothed to prevent interference of surface defects with interpretation of the radiograph, then lead shot is taped close to the weld on both sides to serve as reference points. The gage with its necessary shims is taped to the surface of the plate as is an identification mark. Although a single radiograph will show the soundness of the weld, a second exposure made after the cassette has been shifted a pre-determined amount enables the flaws to be located stereoscopically.

Standard exposures and developments are essential to obtain optimum results. Among the defects detected are porosity, poor fusion, and cracks. If a large number of radiographs are made, a simple identification system is helpful; *i.e.* NP-NS indicates no porosity, no slag. JZB (4)

Hydrogen in Steels

"Determinations of Hydrogen in Ferrous Materials by Vacuum Extraction at 800° C. and by Vacuum Fusion." Vernon C. F. Holm & John G. Thompson. *J. Res. Nat. Bur. Standards,* Vol. 26, Mar. 1941, pp. 245-258. Research.

The vacuum fusion method yields accurate results in the analysis of materials, like cathode iron, which contain hydrogen in a stable form and in considerable amounts. With pressuremetric analysis of the gases, the method is not so satisfactory for the determination of the small amounts of hydrogen that are present in ordinary commercial steels, because of the difficulty of determining these small amounts of hydrogen in the presence of large amounts of oxygen and nitrogen.

Unsatisfactory results are obtained in the analysis of samples that contain unstable hydrogen from electrolysis or from heating in hydrogen because of loss of hydrogen during the extended outgassing that is necessary to bring the blank correction to satisfactory low and constant values. The method of warm extraction at 800° C. yields satisfactory results for a variety of steels of high and low hydrogen contents.

Two advantages of the warm extraction method are (1) speed of operation, which improves the determination of fugitive hydrogen contents, and (2) evolution of hydrogen-rich gases from the specimen regardless of its contents of oxygen and nitrogen, which simplifies the determination of small amounts of hydrogen. The fugitive nature of hydrogen introduced by cathodic charging or by heating in hydrogen at elevated temperatures necessitates immediate analysis. Such materials lose as much as 90% of their hydrogen during a few days' storage at room temperature. The high-hydrogen contents of electrodeposited iron are more stable, but even this material loses hydrogen when the storage time is measured in months.

High hydrogen contents produced by electrodeposition of hydrogen on the surface of solid metal are much more fugitive than similar contents produced by codeposition of iron with the hydrogen. Hydrogen contents of ordinary ferrous materials after extended storage at room temperature, particularly if they were hot-worked in fabrication, usually approximate the solubility of hydrogen in iron at room temperature and therefore are stable.

Analysis of long rods of seven mild steels and an ingot iron failed to reveal evidences of transverse or longitudinal segregation of the hydrogen. WAT (4)

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trends

By Edwin F. Cone, Editor

Heat-Treating Furnaces

Electric heat-treating furnaces sold in 1940 included 2,880 units at $8,238,613 against 1,713 units at $2,928,774 in 1939 and 1,782 units at $1,119,440 in 1938, according to the Industrial Furnace Manufacturers Association.

Molybdenum

The curve of sales of molybdenum continues upward, says the president of the Climax Molybdenum Co. For the first quarter of this year they amounted to 4,700,000 lbs. Sales for the full year of 1940 were 16,300,000 lbs. The refining capacity of the company's plant is being increased.

The Tool Engineers

The American Society of Tool Engineers has chartered its 42d chapter at Hamilton, Ontario—evidence of the rapid growth of this comparatively new society. Too many local chapters in the aggregate of all the technical societies!

Expansion in Aircraft

The American aircraft manufacturing industry increased its production capacity 28 per cent in the first quarter of this year, according to the Aeronautical Chamber of Commerce. A survey of facilities shows production floor space in operation by plane, engine and propeller companies on March 1 to have been 24,122,230 sq. ft. compared with 18,782,879 sq. ft. on Jan. 1. This means a large increase in the consumption of metals and alloys.

Welding Rods

Production of electric arc welding rods is expanding. According to a statement of the manufacturers of these rods, the installation of a relatively small amount of new equipment insures the production of about 400,000,000 lbs. annually. This is roughly twice the quantity used in 1940.

Ferromanganese

A new high in ferromanganese production by American blast furnaces is revealed for April by the monthly blast furnace data collected by *The Iron Age*. In that month 56,871 net tons is reported, a new high for any month. This compares with an average monthly output for 1940 of 29,474 tons. The rate for the first 4 months this year is 43,324 tons monthly. With steel ingot operations at over 99 per cent of capacity, this large output of ferromanganese is essential.

Conservation of Manganese

An important factor in the conservation of manganese, according to testimony at the annual conference of open-hearth men, must be cooperation between producers and consumers. Manganese is important in steel in its effect on rolling properties and surface quality. There are many cases where less manganese can be used if concessions on the part of consumers as to rolling properties and surface quality can be obtained. This will also involve certain changes in specifications.

Steel Company Earnings

For the first year since 1937, the net earnings of the American steel industry were greater last year than aggregate taxes accrued and paid in the period, says an analysis by *Steel*. Twenty-three major producers, representing more than 90 per cent of the industry, reported combined net income before dividend requirements on preferred stock as $257,688,663 with taxes at $208,644,842. By contrast total taxes paid by the same companies in 1939 at $134,762,731 were 3 per cent greater than their combined net income of $130,408,462.

X-Ray Inspection

An example of the extent to which the X-ray examination of materials is expanding is emphasized by a recent statement of the Lockheed Aircraft Corp., Burbank, Calif., that a battery of four chrome-trimmed, fully automatic X-ray machines—"the only equipment of this kind in the world"—is radiographing as high as 20,000 aluminum castings per 24-hr. day.

Pig Iron

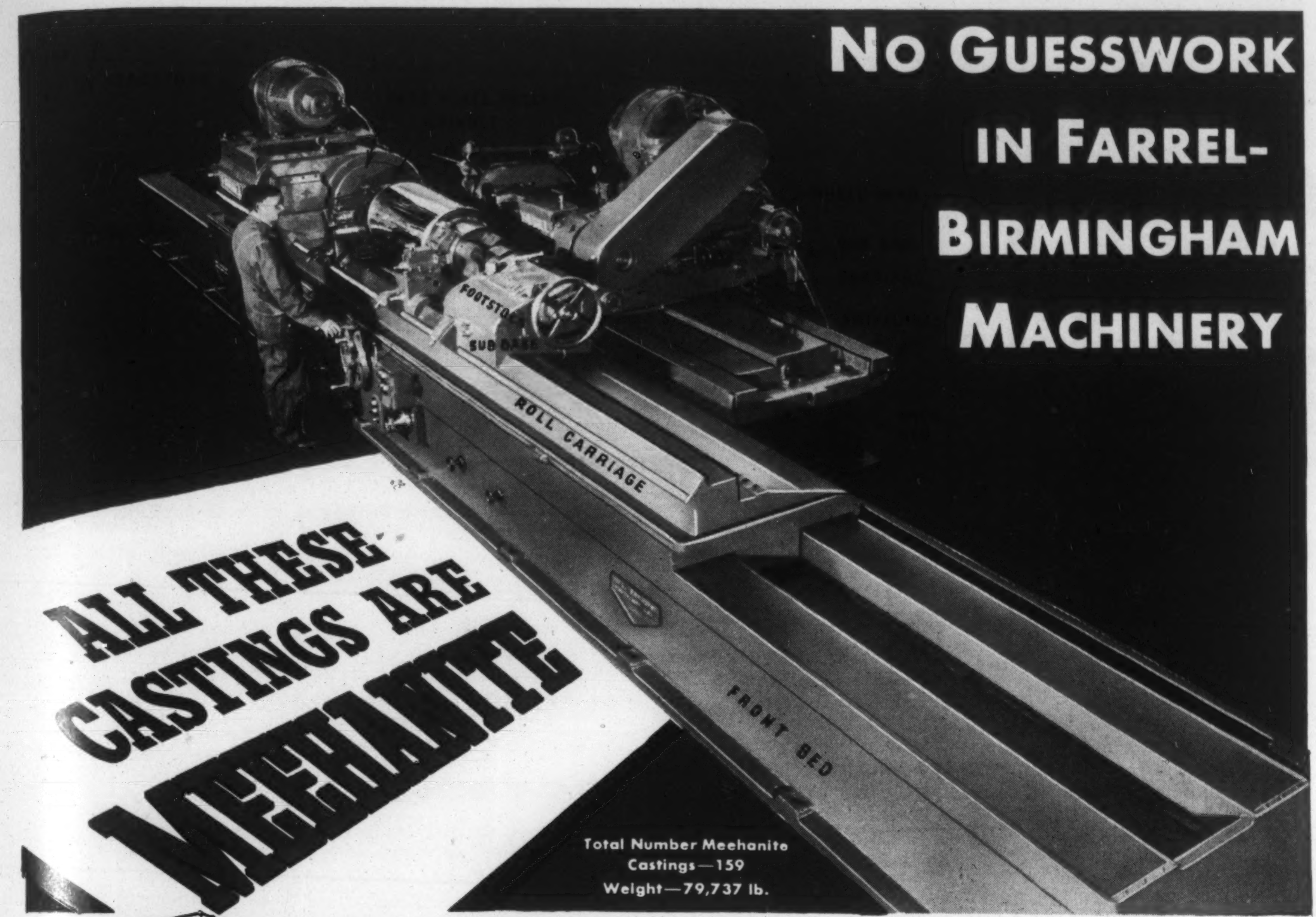
A new peak in coke pig iron production by American blast furnaces was reached in March according to the monthly statistics of *The Iron Age*. The total was 4,704,135 net tons or 152,750 tons per day, a gain of 2.8 per cent over the February total. There were also more furnaces in blast on April 1 than on March 1 or 205 against 202. That the April and perhaps May statistics are likely to be far less favorable is to be laid at the door of the coal strike.

Shipments of Steel

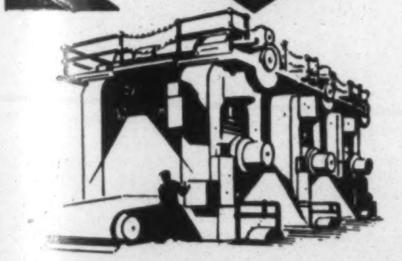
As indicating the trend in demand for steel, shipments of finished steel products by the Steel Corp. in March totaled 1,720,366 net tons, a record for that organization. Previous record was 1,701,874 tons in May, 1929.

(Additional "Trends" on page 822)

NO GUESSWORK IN FARREL-BIRMINGHAM MACHINERY



Total Number Meehanite Castings—159
Weight—79,737 lb.



Products of Farrel-Birmingham Company, Inc., Ansonia, Conn., like this Type TT Roll Grinder, are designed and engineered scientifically to *exact* specifications throughout. ***MEEHANITE*** castings contribute their share to exactness, accuracy, durability—because the ***MEEHANITE*** processes are themselves scientific, eliminating guesswork in casting production and providing the needed engineering and physical properties, carefully controlled and combined to meet the requirements of the job. Result: better machinability—freedom from structural defects—superior wear resistance—higher strengths.

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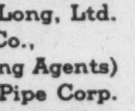

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Cleveland, Ohio	Fulton Foundry & Machine Co.
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Flint, Mich.	General Foundry & Mfg. Company
Hamilton, Ohio	Hamilton Foundry & Machine Co.
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Pittsburgh, Pa.	Rosedale Foundry & Machine Co.
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trends

By Edwin F. Cone, Editor

Recovery of Tin

A committee on the recovery of tin, of which F. W. Willard is chairman, has made a report to the Office of Production Management. The report states that a maximum of 12,000 long tons of tin might be recovered annually in the United States from used tin cans, but advises against the establishing of any new detinning plants. This maximum of 12,000 tons of recoverable tin compares with about 70,000 tons consumed during 1939. The cost of collection is so high that utilization of used cans would be a last resort.

In a supplement to the report, it is stated that the use of non-metallic containers is increasing substantially, that tin plate bearing less than 1 per cent Sn is being used for dry-pack materials, that active research is rapidly approaching a stage where suitable non-metallic coatings for sheet steel will be available for certain products now preserved in tin plate containers, and that the use of tin in soft solders is decreasing.

This is being carried further in a later development by plans to cut the weight of coating by 10 per cent on tinplate for general food packing (except for baby food, kraut, cherries, and a few other active packs comprising only some 5 per cent of the total), to pack all save white or very light tints of paint in terne rather than tin, and to use black plate where feasible, as in ends for oil cans. These changes will be made voluntarily by the can makers if the situation requires and some of them will be made anyway.

Saving Zinc in Brass Pipe

Practically all of the manufacturers of brass pipe have discontinued the production of yellow brass pipe and are concentrating on the red brass alloy for this product, according to a survey of the Copper & Brass Research Assn. Red brass pipe has only about 15 per cent Zn whereas the yellow alloy contains 30 to 40 per cent. The saving in substituting the red for the yellow brass is estimated to total about 4,000 tons each year, on the basis of the 1940 sales of yellow brass pipe. This zinc is thus made available for National Defense, sufficient to produce more than 25,000,000 lbs. of cartridge brass.

Chrom-X

The use of the new exothermic alloy of chromium, "Chrom-X" made from low grade domestic chromium ores, is on the increase and with satisfactory results. Testimony at both the basic and acid open-hearth sessions during the annual open-hearth conference in Chicago in April, was almost unanimously to the effect that Chrom-X was being successfully used in producing both 1 per cent and 4 to 6 per cent Cr steels with chromium recovery as high as 95 to 96 per cent.

Open-Hearth Furnace Doors

The use of monolithic lined doors for open-hearth furnaces is on the increase, according to testimony at the open-hearth conference in Chicago in April. Several operators produced evidence of longer life with such doors.

Brick for Open-Hearth Furnaces

More open-hearth furnace builders are using 3-in. instead of 2½-in. brick in construction operations, according to the experience of some of those attending the open-hearth conference in Chicago recently. Saving of time in construction is a prime advantage.

Insulation of Open-Hearths

Gains from the use of insulation on open-hearths are at least holding, said operators at the April convention of open-hearth men. Use of insulated roofs of furnaces is reported advantageous though there is fear on the part of some to adopt this practice.

Pit Furnaces

A barometer of the modernization trend in the steel industry during the last 5 yrs., and of the intense current tempo for rehabilitation and improvement is believed seen in the furnace building activity of a Pittsburgh company. This company reported recently (about April 15) that it had a total of 36 soaking pits on order or under construction. Since March, 1936, this company has installed or received orders for 107 pit furnaces, most of them of the extra large size, with a total estimated heating capacity of over 8,000,000 tons of ingots per year.

Plastics and Metals in Airplanes

Discussing plastics in airplanes, Dr. A. Allen Bates, manager of chemical and metallurgical research, states in the *Westinghouse Magazine* that after the war a flood of small plastic plywood planes will come off this country's production lines at prices many people can afford, boosting the aircraft industry. The plastic used in these small planes, he says, is actually a laminated plywood bound together with resin—a combination that is fast replacing the older forms of plywood because of its strength and durability. Larger planes, he emphasizes, will probably be made of metal for many years to come. He expects that the advent of the flivver plane will make Americans so much more air-minded that commercial air travel will decidedly increase, with a resultant demand for more and more of the all-metal planes.

(Other "Trends" on page 820)

METALS and ALLOYS

Volume XIII—January, 1941 to June, 1941

SUBJECT INDEX

Aircraft—Welding Engine Mounts for Martin Bombers.—Herbert Chase. 559 May

Aircraft Engines, Aluminum Alloy Cylinder Heads for. 570 May

Alloy and Electric Steel in 1940.—Edwin F. Cone. 726 June

Aluminum Alloy Cylinder Heads for Aircraft Engines. 570 May

Aluminum-Copper-Nickel-Zirconium Alloys.—Ernest F. Nippes. 294 Mar.

Aluminum, Diffusion in Alpha Solid Solutions of.—R. F. Mehl, F. N. Rhines and K. A. von den Steinen. 41 Jan.

Cast Iron, Class 40—Corrosion Fatigue of Notched Specimens.—H. W. Russell & J. G. Lowther. 169 Feb.

Cast Iron, A Deflectometer for Transverse Testing of. C. T. Greenidge & E. C. Kron. 723 June

Cast Iron Pipe, Producing, Centrifugally.—Don Graf & Edwin F. Cone. 155 Feb.

Cast Iron and Steel, Hydrogen in.—C. A. Zapffe & C. E. Sims. 444, 584, 737 Apr., May, June, (July)

Castings, Special-Iron, for Heavy Machinery—A Pictorial Account.—S. S. Board, Jr. 36 Jan.

Cobalt-Copper-Silicide Alloys, Two Complex.—F. R. Hensel, E. I. Larsen and E. F. Holt. 151 Feb.

Copper and Nickel, Alloyed with Electrolytic Manganese.—B. L. Averbach, 730 June, (July)

Copper-Tungsten for Electrical Contacts—Properties of Various Compositions.—F. R. Hensel, E. I. Larsen & E. F. Swazy. 577 May

Copper-Cobalt-Silicide Alloys, Two Complex.—F. R. Hensel, E. I. Larsen and E. F. Holt. 151 Feb.

Copper-Nickel-Zirconium-Aluminum Alloys.—Ernest F. Nippes. 294 Mar.

Corrosion Fatigue of Notched Specimens—Class 40 Cast Iron.—H. W. Russell & J. G. Lowther. 169 Feb.

Cylinder Bores, Induction-Hardened.—Fred P. Peters & Edwin F. Cone. 713 June

Cylinder Heads for Aircraft Engines, Aluminum Alloy. 570 May

A Deflectometer for Transverse Testing of Cast Iron.—C. T. Greenidge & E. C. Kron. 723 June

Die Castings in Magnesium Alloy.—Herbert Chase. 145 Feb.

Diffusion in Alpha Solid Solutions of Aluminum.—R. F. Mehl, F. N. Rhines and K. A. von den Steinen. 41 Jan.

Editorials
- A New Year—Jan.
- Light Weight Rolling Stock—Jan.
- Manganese—Jan.
- The Cabots Speak only to Cabots—Feb.
- Electric Steel Capacity—Feb.
- "Rare and Minor Metals"—Mar.
- Priorities, Plastics and "the Peace"—Mar.
- Substitutes—April
- That Old Proportional Limit—April
- Youth and Age—April
- What's an Engineer?—May
- Mind your own Business?—May
- From Special Steels to Machine Tools—May
- If the Shoe Fits—June
- The Order of Judas Iscariot—June

Electric and Alloy Steel in 1940.—Edwin F. Cone. 726 June

Electrical Heat Treatment of Rivet Studs.—L. C. Conradi. 284 Mar.

Electrical Resistance Furnaces for High Temperatures.—Paul Schwarzkopf. 45 Jan.

Electrolytic Manganese Alloyed with Copper and Nickel.—B. L. Averbach. 730 June, (July)

Electrolytic Polishing of Steel Specimens.—G. F. Meyer, G. D. Rahrer & J. R. Vilella. 424 Apr.

Forgings versus Welded Assemblies—J. A. Petrie & George W. Papen. 734 June

Furnace, Special Heat Treating, for Military and Other Parts.—Horace C. Knerr. 49 Jan.

Furnaces, Electrical Resistance, for High Temperatures.—Paul Schwarzkopf. 45 Jan.

Heat Treatment, Electrical, of Rivet Studs.—L. C. Conradi. 284 Mar.

Heat Treatment of Steel Castings—Early History.—John Howe Hall. 563 May

A Holder for Metallographic Specimens During Polishing.—George R. Kauffman. 171 Feb.

Hydrogen in Steel and Cast Iron.—C. A. Zapffe & C. E. Sims. 444, 584, 737 Apr., May, June, (July)

Induction-Hardened Cylinder Bores.—Fred P. Peters & Edwin F. Cone. 713 June

Letters to the Editor
- The Iron Powder Situation. 51 Jan.
- Metals and Alloys in the Dairy Industry. 173 Feb.
- Tin Plate and Solder. 174 Feb.
- Bearing Metals. 174 Feb.
- Counter-Espionage Activity. 301 Mar.
- Failure of Low Carbon Steel Tubes. 449 April
- Metallography of Tin and Tin Coatings. 449 April
- 18:8 and Notched Fatigue. 450 April
- Metals and Alloys in the Dairy Industry. 450 April

Low-Alloy, High Strength Steels, The Present Status of the.—Edwin F. Cone. 273 Mar.

Magnesium Alloy, Die Castings in.—Herbert Chase. 145 Feb.

Magnesium Alloys in Industry.—John C. Mathes. 23 Jan.

Manganese, Electrolytic, Alloyed with Copper and Nickel.—B. L. Averbach. 730 June, (July)

Metallography of Tin and Tin Coatings on Steel.—O. E. Romig & D. H. Rowland. 436 Apr.

Nickel and Copper, Alloyed with Electrolytic Manganese.—B. L. Averbach. 730 June, (July)

Nickel-Zirconium-Aluminum-Copper Alloys.—Ernest F. Nippes. 294 Mar.

Our Electric and Alloy Steel in 1944.—Edwin F. Cone. 726 June

Poetry
- Effect of Temperature on the Minds of Metallurgical Engineers.—J. Tucker MacKenzie & Staff of U. S. Corp. Res. Lab. 52 Jan.
- A Metallurgist's Letter of Application.—Robert L. Nichols. 450 April

Polishing, A Holder for Metallographic Specimens During.—George R. Kauffman. 171 Feb.

Practical Metallography of the Stainless Steels.—Stanley P. Watkins. 31, 162, 288, 431 Jan., Feb., Mar., Apr.

The Present Status of the Low-Alloy, High Strength Steels.—Edwin F. Cone. 273 Mar.

Producing Cast Iron Pipe Centrifugally.—Don Graf & Edwin F. Cone. 155 Feb.

Rivet Studs, Electrical Heat Treatment.—L. C. Conradi. 284 Mar.

Silicide Alloys, Two Complex Copper-Cobalt.—F. R. Hensel, E. I. Larsen & E. F. Holt. 151 Feb.

Special Heat Treating Furnace for Military and Other Parts.—Horace C. Knerr. 49 Jan.

Special-Iron Castings for Heavy Machinery—A Pictorial Account.—S. S. Board, Jr. 36 Jan.

Stainless Steels, Practical Metallography of the.—Stanley P. Watkins. 31, 162, 288, 431 Jan., Feb., Mar., Apr.

Steel and Cast Iron, Hydrogen in.—C. A. Zapffe & C. E. Sims. 444, 584, 737 Apr., May, June, (July)

Steel, Making, in the U. S. S. R., Trends and Experiments in.—S. L. Case. 419 Apr.

Steel Castings, Heat Treatment of—Early History.—John Howe Hall. 563 May

Steel Specimens, Electrolytic Polishing of.—G. F. Meyer, G. D. Rahrer & J. R. Vilella. 424 Apr.

Tin and Tin Coatings on Steel, Metalography of.—O. E. Romig & D. H. Rowland. 436 Apr.

Transverse Testing of Cast Iron, A Deflectometer for.—C. T. Greenidge & E. C. Kron. 723 June

Trends and Experiments in Making Steel in the U. S. S. R.—S. L. Case. 419 Apr.

Tungsten-Copper for Electrical Contacts—Properties of Various Compositions.—F. R. Hensel, E. I. Larsen & E. F. Swazy. 577 May

Two Complex Copper-Cobalt-Silicide Alloys.—F. R. Hensel, E. I. Larsen & E. F. Holt. 151 Feb.

Welded Assemblies, Forgings versus.—J. A. Petrie & George W. Papen. 734 June

Welding Engine Mounts for Martin Bombers—Herbert Chase. 559 May

Zirconium-Aluminum-Copper-Nickel Alloys.—Ernest F. Nippes. 294 Mar.

AUTHOR INDEX

Averbach, B. L.—Electrolytic Manganese Alloyed with Copper and Nickel. 730 June, (July)

Board, Jr., S. S.—Special-Iron Castings for Heavy Machinery—A Pictorial Account. 36 Jan.

Case, S. L.—Trends and Experiments in Making Steel in the U.S.S.R. 419 Apr.

Chase, Herbert—Die Castings in Magnesium Alloy. 145 Feb.

——— ———Welding Engine Mounts for Martin Bombers. 559 May

Cone, Edwin F.—Our Electric and Alloy Steel in 1940. 726 June

——— ———The Present Status of the Low-Alloy, High Strength Steels. 273 Mar.

——— ——— **& Graf, Don**—Producing Cast Iron Pipe Centrifugally. 155 Feb.

——— ——— **& Peters, Fred P.**—Induction-Hardened Cylinder Bores. 713 June

Conradi, L. C.—Electrical Heat Treatment of Rivet Studs. 284 Mar.

Graf, Don & Cone, Edwin F.—Producing Cast Iron Pipe Centrifugally. 155 Feb.

Greenidge, C. T. & Kron, E. C.—A Deflectometer for Transverse Testing of Cast Iron. 723 June

Hall, John Howe—Heat Treatment of Steel Castings—Early History. 563 May

Hensel, F. R.; Larsen, E. I. & Holt, E. F.—Two Complex Copper-Cobalt-Silicide Alloys. 151 Feb.

——— ———; ——— ——— **& Swazy, E. F.**—Tungsten-Copper for Electrical Contacts—Properties of Various Compositions. 577 May

Holt, E. F.; Hensel, F. R. & Larsen, E. I.—Two Complex Copper-Cobalt-Silicide Alloys. 151 Feb.

Kauffman, George R.—A Holder for Metallographic Specimens During Polishing. 171 Feb.

Knerr, Horace C.—Special Heat Treating Furnace for Military and Other Parts. 49 Jan.

Kron, E. C. & Greenidge, C. T.—A Deflectometer for Transverse Testing of Cast Iron. 723 June

Larsen, E. I.; Hensel, F. R. & Holt, E. F.—Two Complex Copper-Cobalt-Silicide Alloys. 151 Feb.

——— ———; ——— ——— **& Swazy, E. F.**—Tungsten-Copper for Electrical Contacts—Properties of Various Compositions. 577 May

Lowther, J. G. & Russell, H. W.—Corrosion Fatigue of Notched Specimens—Class 40 Cast Iron. 169 Feb.

Mathes, John C.—Magnesium Alloys in Industry. 23 Jan.

Mehl, R. F.; Rhines, F. N. & von den Steinen, K. A.—Diffusion in Alpha Solid Solutions of Aluminum. 41 Jan.

Meyer, G. F.; Rahrer, G. D. & Vilella, J. R.—Electrolytic Polishing of Steel Specimens. 424 Apr.

Nippes, Ernest F.—Copper-Nickel-Zirconium-Aluminum Alloys. 294 Mar.

Papen, George W. & Petrie, J. A.—Forgings versus Welded Assemblies. 734 June

Peters, Fred P. & Cone, Edwin F.—Induction-Hardened Cylinder Bores. 713 June

Petrie, J. A. & Papen, George W.—Forgings versus Welded Assemblies. 734 June

Rahrer, G. D., Vilella, J. R. & Meyer, G. F.—Electrolytic Polishing of Steel Specimens. 424 Apr.

Rhines, F. N.; von den Steinen, K. A. & Mehl, R. F.—Diffusion in Alpha Solid Solutions of Aluminum. 41 Jan.

Romig, O. E. & Rowland, D. H.—Metallography of Tin and Tin Coatings on Steel. 436 Apr.

Rowland, D. H. & Romig, O. E.—Metallography of Tin and Tin Coatings on Steel. 436 Apr.

Russell, H. W. & Lowther, J. G.—Corrosion Fatigue of Notched Specimens—Class 40 Cast Iron. 169 Feb.

Schwarzkopf, Paul—Electrical Resistance Furnaces for High Temperatures. 45 Jan.

Sims, C. E. & Zapffe, C. A.—Hydrogen in Steel and Cast Iron. 444, 584, 737 Apr., May, June, (July)

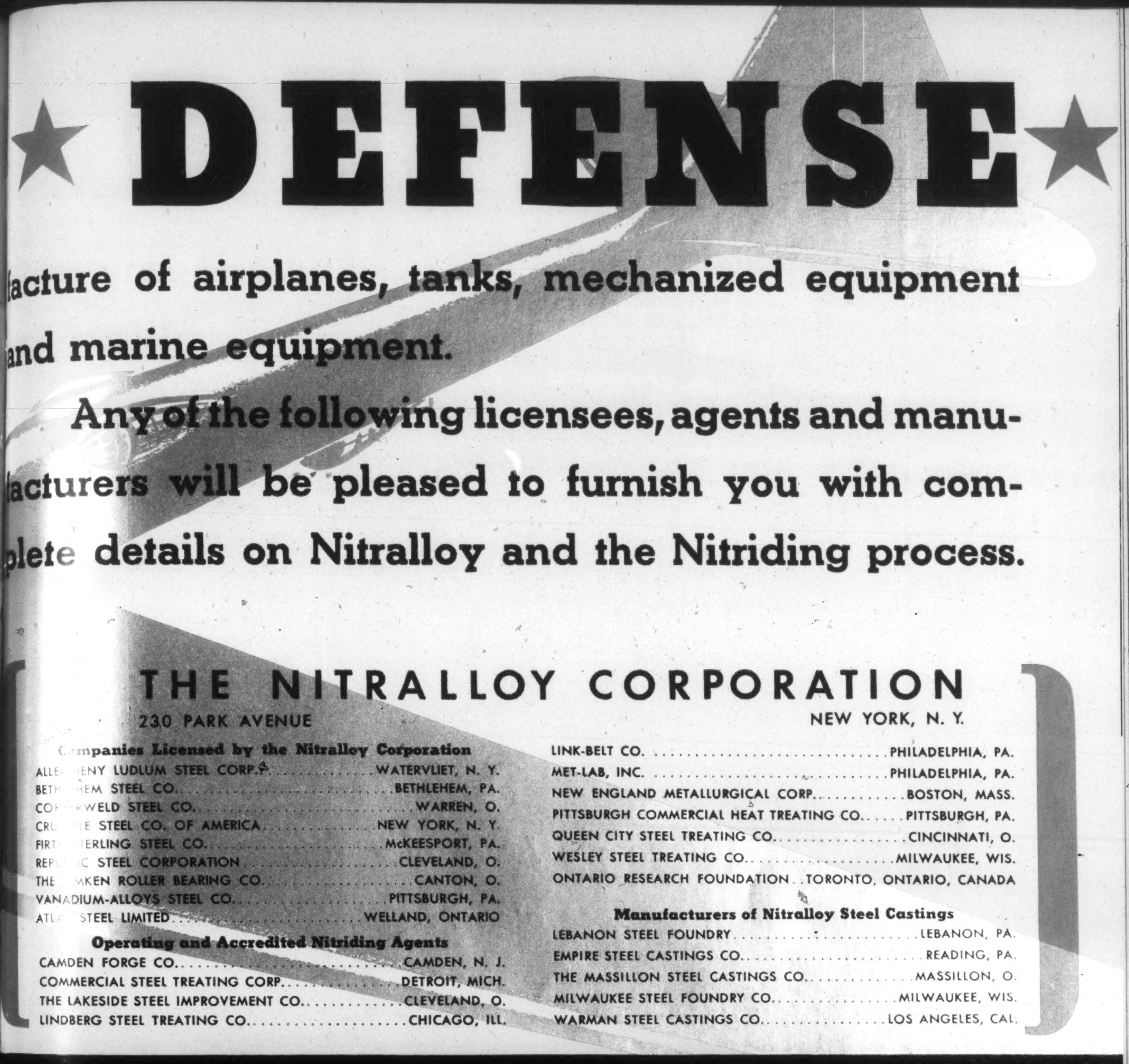
von den Steinen, K. A.; Mehl, R. F. & Rhines, F. N.—Diffusion in Alpha Solid Solutions of Aluminum. 41 Jan.

Swazy, E. F.; Hensel, F. R. & Larsen, E. I.—Tungsten-Copper for Electrical Contacts—Properties of Various Compositions. 577 May

Vilella, J. R.; Meyer, G. F. & Rahrer, G. D.—Electrolytic Polishing of Steel Specimens. 424 Apr.

Watkins, Stanley P.—Practical Metallography of the Stainless Steels. 31, 162, 288, 431 Jan., Feb., Mar., Apr.

Zapffe, C. A. & Sims, C. E.—Hydrogen in Steel and Cast Iron. 444, 584, 737 Apr., May, June, (July)



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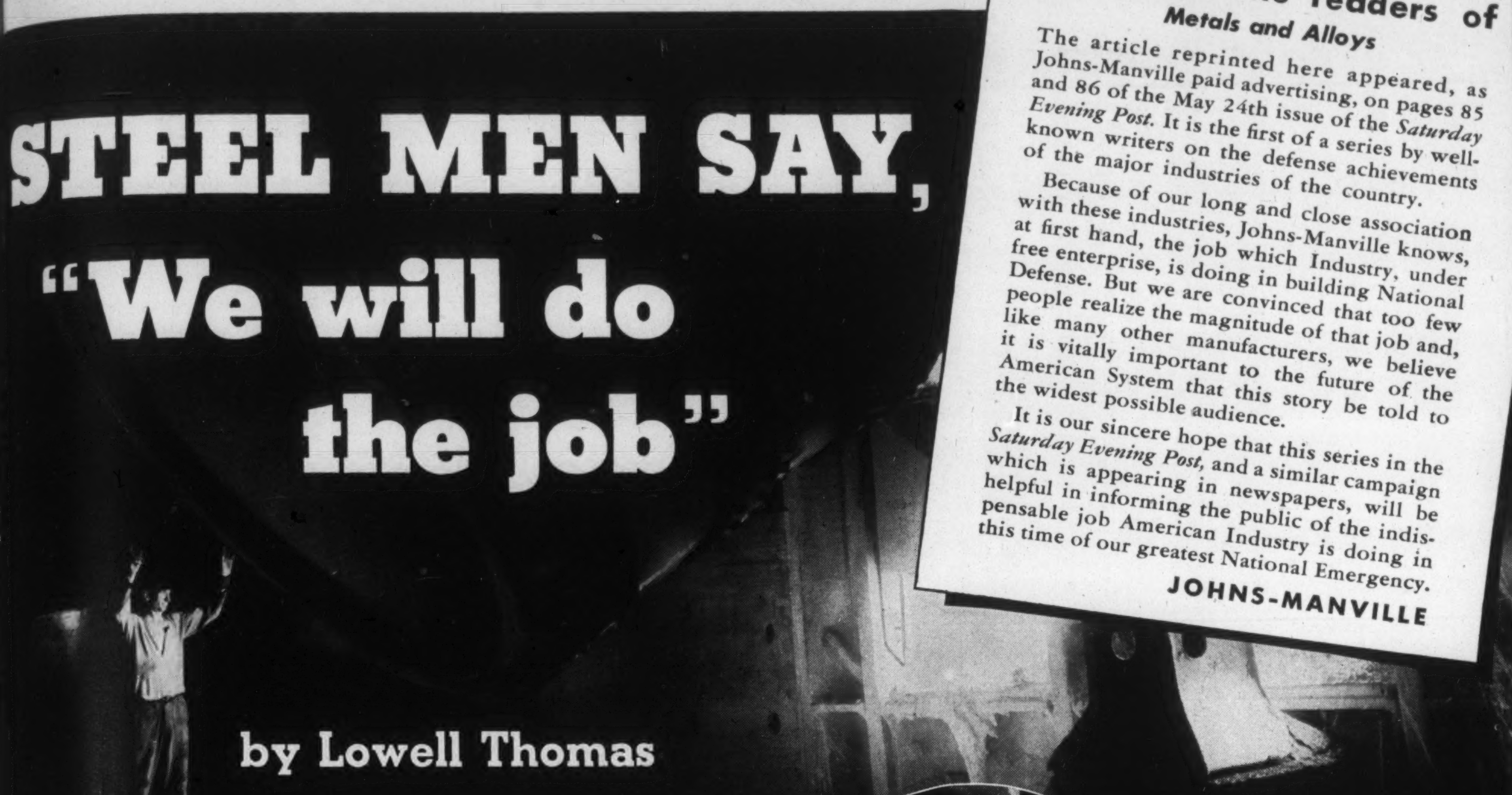


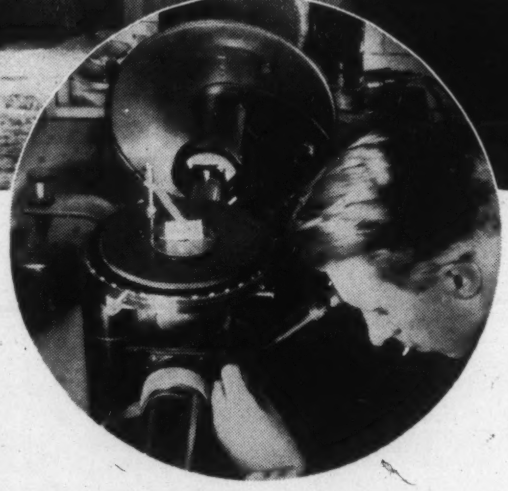
A note to the readers of *Metals and Alloys*

The article reprinted here appeared, as Johns-Manville paid advertising, on pages 85 and 86 of the May 24th issue of the *Saturday Evening Post*. It is the first of a series by well-known writers on the defense achievements of the major industries of the country.

Because of our long and close association with these industries, Johns-Manville knows, at first hand, the job which Industry, under free enterprise, is doing in building National Defense. But we are convinced that too few people realize the magnitude of that job and, like many other manufacturers, we believe it is vitally important to the future of the American System that this story be told to the widest possible audience.

It is our sincere hope that this series in the *Saturday Evening Post*, and a similar campaign which is appearing in newspapers, will be helpful in informing the public of the indispensable job American Industry is doing in this time of our greatest National Emergency.

JOHNS-MANVILLE



It all starts like this. Above—A giant ladle pours 100 tons of molten pig iron into an Open-Hearth Steel Furnace.

•

Left—Investment for the Future. One of Steel's 2,550 research men looks through a metallurgical microscope.

WHAT about defense? When I left New York for the Front—the Front of Steel—in Pittsburgh and Ohio, the words of Ben Fairless were still echoing in my ears, "Never mind the alarmists. *Steel will do the job.*"

But I was a little bewildered—maybe even a little skeptical, even though Fairless is President of U. S. Steel and ought to know.

After all, I am not an economist. I am not even a steel man. I have, like most Americans, a complete faith in native American ingenuity and "drive." But I had talked to men in Washington who told me steel "did not have nearly enough capacity to meet normal demands plus the needs of National Defense."

This was before the Gano Dunn report had been made to the President—the official report which said that we will have enough of most kinds of steel, both for war and commerce, even if the national income climbs to 90 billion dollars. (Last year it was 74 billion plus.)

Then, of course, there's always the "laborquestion"—Yes, it's just one word the way people use it. But there wasn't any "laborquestion" when I was going through the Armco plant (American Rolling Mill Co.) at Middletown, Ohio, the next morning. There were just some Americans, most of them in the kind of fine physical condition that makes office workers and radio broadcasters envious. And these Americans have, I assure you, got what it takes. It's in the atmosphere all around them. They have morale. They have that something that can't be faked. It's what Wavell's British Army had in North Africa and what Graziani's army (twice as big) just didn't have.

We stopped to look at a pile of stainless steel sheets ready for shipment to the Navy. Each sheet was covered with a soft, fluffy layer of paper and then with a layer of brown wrapping paper. I asked the nearest steelworker if we could have a look.

Have you ever gone into a really crack artillery regiment and asked to inspect a fieldpiece ready for action? I have. And the man who opens the spotless, perfectly oiled breechblock for you will pack plenty into that gesture. He will pack into it pride. He will pack into it something very close to love. He will, finally, actively resent even the shadow of a criticism of that gun. He will fight *for* that gun as well as with it.

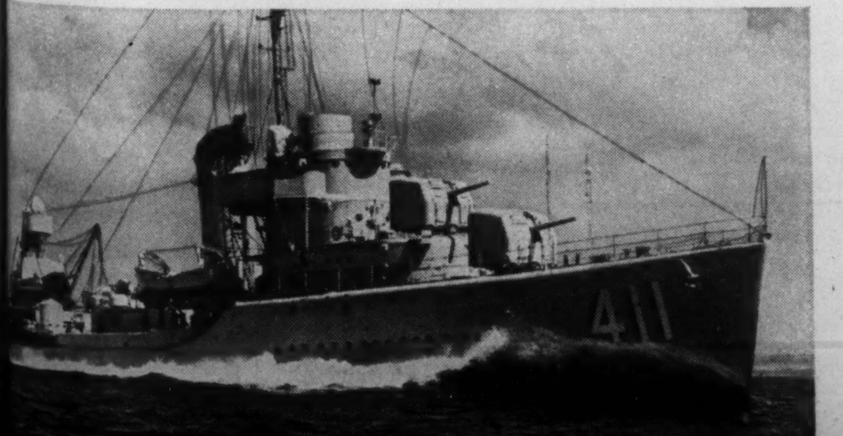
Well, Joe Stouras, ex-football player, husband, father, steelworker of Middletown, Ohio, lifted the paper layers off the top sheet of stainless steel. The man going through the plant with me was filling his pipe . . . One crumb of tobacco fell on the mirror-like surface of that sheet of steel—just one crumb.

Joe Stouras reached out and brushed it off with his middle finger—brushed it off with decision, with a trace of rebuke, with a fine protective gesture of defiance.

"This here order's going to the Navy tonight," he said. "Got to be careful."

Joe Stouras is typical of the men of steel

(*Continued on next page*)



DD411, the U. S. S. ANDERSON, knifes through the water of Penobscot Bay on her full-speed trial run off the coast of Maine. This destroyer was built and delivered to the Navy in advance of contract requirements. The U. S. S. EDISON, referred to in this article, was completed four and a half months ahead of schedule.

This is one of a series of advertisements sponsored and paid for by Johns-Manville. For over 80 years this company has been serving America's basic industries.

How indispensable these industries are to the American way in time of peace is generally recognized. This series is to help inform the public of the indispensable job these industries are doing in this time of great National Emergency.

Johns-Manville is proud of the contributions its products are making in helping steel, as well as other industries, produce defense material quickly and at the lowest possible cost.

JOHNS-MANVILLE

WHAT STEEL MEN SAY

(Continued from preceding page)

to me. Men who are keeping open hearths and blast furnaces running 24 hours a day (three eight-hour shifts). Men who, when an order is posted on the bulletin board marked "National Defense," just "high-tail it into the shop," as one assistant works manager put it to me. And they are American craftsmen, fully aware of the fact that poor quality, just a slight flaw, in armor plate, airplane frame or Navy searchlight reflector may cost an American or British life somewhere, sometime. They know, almost all of them, what Joe meant when he said, "Got to be careful."

I say "almost all of them," because no honest reporter can deny the existence of some unrest, of some disloyalty, even of some sabotage. But, in the words of Irving S. Olds, Chairman of the Board of U. S. Steel, "All but a few of the workers throughout the industry *want* to do the job. And the minority, although they can make trouble, cannot buck that majority's determination to do the job on time—even ahead of time."

Mr. Olds can show you what he means with deeds, not words. He knows; the Government knows; and every American *ought* to know that two destroyers completed last summer by The Federal Shipbuilding and Dry Dock Company, U. S. Steel's shipbuilding subsidiary, were delivered *seven months* ahead of contract requirements . . . The U. S. S. EDISON, one of that company's more recent deliveries, was completed ten and a half months after the keel was laid—4½ months ahead of the contract delivery date.

Can American private enterprise do the job? "Yes," say the men of steel. And they say it with a full-throated voice that will be heard from Bethlehem to Berlin.

Steel is an industry vast in its five-billion-dollar investment; immense in its giant plants and huge machinery, and tremendous in its man power—half a million workers who "bulk big" in stature, a wide-shouldered, thick-thewed multitude, confident of their strength and skill, proud of their trade. And from executive offices to timekeepers' windows, from blast furnace to finishing mill, my tour of steel seemed tuned to the rhythm of an exultant, irresistable drive for national defense.

This drive starts full-powered because during the long doldrums of the depression, here is a private enterprise that spent a billion and a half dollars increasing its capacity in the face of diminishing returns. Because management believed in an expanding America and discounted the idea of a "static economy," the steel industry increased the annual capacity of their plants from sixty-five million tons in 1929 to eighty-five million tons in the somber year of 1940.

Yes, the steel industry is big enough and strong enough, but is it flexible enough?

The Boys Were Cold

An incident told me by Charles Hook, President of the American Rolling Mills, will, I think, answer that.

"On December 5th," said Mr. Hook, "a government man called me up from Washington. 'The boys in the Tennessee camps,' he said, 'are shivering in unheated tents. We are ordering several thousand camp stoves from the Tennessee Enamel Manufacturing Company. I understand you furnish their sheet steel. What kind of priority order do you need?'

"'We don't need any,' I said. 'Order your stoves and leave the rest to us.'

"We called Tennessee and learned the sizes they needed. We supplied most of them from stock. Within a week we had shipped the sheets—250 tons of them. Inside of ten days from the Washington phone call, the boys in the draft camps were snug in their heated tents."

That is flexibility—and it is also speed.

The twenty million tons of steel needed by John Bull and for Uncle Sam's defense is regarded by steel men as no vast amount. Yet this is greater than the total production of any other nation save Germany. And except in relation to our total 85,000,000-ton capacity, it *is* an enormous volume of steel. It will take half a million cars to ship it, and they would make a freight train six thousand miles long.

And it isn't, of course, mere bulk and weight like coal and ore and limestone. It is in thousands of shapes and sizes, from rough ingots to stainless-steel needles for hypodermic syringes, and from eighteen-inch armor plate to sheets that are used in making plane generators—sheets so thin you can typewrite on them. With all its multiplicity and complexity, steel is being fabricated on schedule and delivered on time—whether it's 100 tons for hobnailed shoes, fifty thousand tons of structural steel for a new tank factory, or fifty pounds of tiny, microscopically finished steel springs for the innards of a torpedo.

The men of steel, from top to bottom, don't talk much. They're too busy getting the job done. I left the office of one prominent steel executive late on a Friday afternoon with a mountain of work on his desk high enough to chain him there until Sunday night. There is no "weekend blackout" in steel, for management or labor.

Director General of Production Knudsen said last January, "If we are willing to spend a little sweat for a year or so, then we may be able to save a little blood later on." Steel is spending sweat, right now. In the plant, and in the offices, far into the night. And in the laboratory. Research is, in truth, the universal ingredient that goes into every "heat" in steel's furnaces, and enters into every process from the ore and coal mines to the ultimate consumer. Only in the chemical industry does the laboratory function so incessantly and microscopically as in metallurgy.

And in no other business is the research equipment so varied and so expensive. It ranges from scales that will weigh a wisp of mist to machines that will pull a one-inch tool-steel bar apart. Research is responsible for the development of every high-speed steel and every alloy that gives the machine age its infinite variety. Research, for example, reduced the weight of airplane engines from the twenty-one pounds per horse power of the Wrights' *Kittyhawk* to the one-pound-per-horse-power of a modern motor. If only I were at liberty to tell you about other, and even more amazing, achievements I saw or heard about "behind the scenes."

Then, of course, I asked executive after executive, "Are there any bottlenecks in steel?" They answered this way: "All steel needs is to know what is required for defense. We'll find a way to take care of it."

Here, for example, is one way they deal with shortages. If any one alloying agent, molybdenum, tungsten, chromium or vanadium, becomes scarce, steel's research staffs find means of substituting and shuffling them about to get the same results by different combinations. Steel companies' scouts are always finding new sources of supply for their engineers to develop.

Perhaps I ought to break in here, and explain that there is, in steel, no disposition to belittle the importance of governmental authorities in the vast panorama of steel. Steel men contend only that the most efficient and satisfactory functioning of the tremendous defense machine results when government leaves actual operations to the ingenuity, initiative and adaptability of men educated in a competitive school of change and progress.

Those qualities can respond to sudden stress with the resiliency of a fine steel spring. Less than a year ago, steel executives sensed—long before an emergency developed—that electric-furnace capacity was not adequate to future requirements. Only 1½% of steel production comes from these furnaces, but that small per cent comprises nearly all the fine steels for high-speed machine tools, airplane engines and instruments, and bomb and gun sights. Today electric-furnace capacity is fifty per cent greater than that of early 1940 and further increases are keeping in step with defense demands.

In my search for the facts, one of my most valuable sources proved to be W. S. Tower, President of the American Iron and Steel Institute and Ambassador of Steel to the United States Government. The Institute has a membership of more than 90 operating steel companies and performs an indispensable function in making it possible for these vast enterprises to operate as one great industry in National Defense. Mr. Tower's confidence that steel can do the job is not based on hope, but on a great volume of hard, cold statistics he has constantly at his fingertips.

A New Crop of Millionaires?

"—And how about a new group of multi-millionaires?" I asked Mr. Tower. "Is rearmament going to make us any?" "Not in steel," said Mr. Tower. "For big figures no longer mean big *profits*. Steel is a *five-billion-dollar* business. . . That's how much capital (savings) is invested in it. But for the past ten years, it has earned only an average of 2% on that investment.

"As for this year, well, steel is spending $282,000,000 for plant expansion and equipment, for one thing. For another, steel, right now, is employing 20 per cent more men than in 1929."

"And what about the men of that steel army?" I asked.

"Hourly wages in steel today are nearly 50% higher than in 1929. Also, between 1926 and 1939, the average severity of accidents was reduced 35%. One out of every three severe accidents that used to happen doesn't happen any more."

TO SUM UP:—It seems to me that this titan industry is demonstrating its fitness for a titanic task. It has the scientific management, the skilled workers, the materials, the capacity and the production.

Somehow the roar and rumble of the mills and forges, the hiss and crackle of molten metal, the blast of furnaces and converters, mingle in one sound, and that sound is the Voice of Steel.

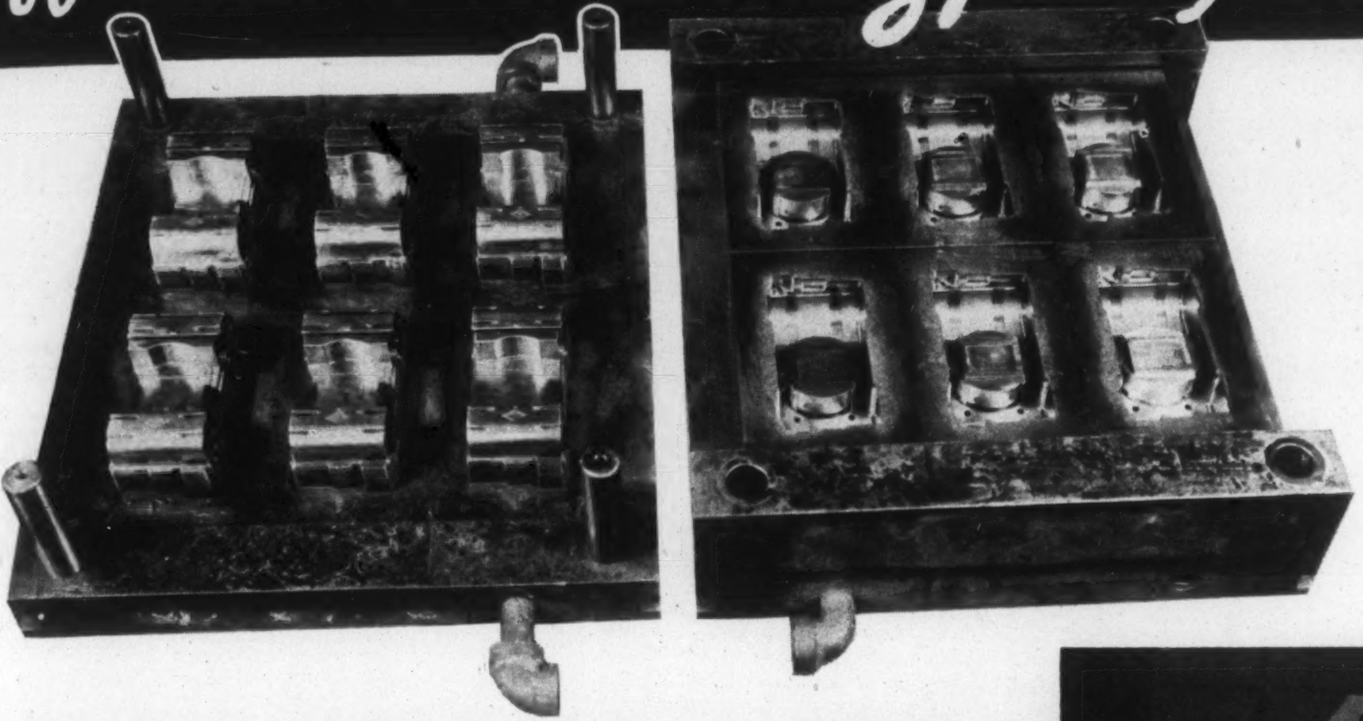
Winston Churchill said, "Give us the tools, and we will do the job."

The Voice of Steel can say, for its part in the defense program, "We *have* the tools, and we will do the job."

This is the first of a series of advertisements sponsored and paid for by Johns-Manville and designed to tell the American people how indispensable our basic industries are for National Defense.

— JOHNS-MANVILLE —

"We knock days off mold machining time and dollars off steel costs with Speed Treat"



reports Chicago Molded Products Corp.

By using pack hardened *Speed Treat* Steel Plate (X1545) for the stripper plates and a moly steel for the molds only, this pioneer plastics molding firm has greatly reduced machining time and steel costs as well.

Instead of using a hard-to-machine steel throughout, the stripper plates are made of free machining *Speed Treat* with the machined mold keyed to the plates.

Speed Treat has high tensile strength, resistance to impact and abrasion, assures minimum distortion in machining and heat treating, has a fine finish as machined, greatly increases tool life, machines at 135-145 s.f.p.m.

Speed Treat is ideal for plastics and rubber mold and die-casting die work because it withstands constant temperatures up to 700° without checking.

It responds readily to any heat-treating that can be applied to .30-.40 or .40-.50 carbon steel and has the additional advantage of being water quenched. *Speed Treat* can be flame hardened, forged and welded. Many mold and die shops have found it expedient to make the entire mold of *Speed Treat* (X1545) or *Speed Case* (X1515) with satisfactory results, not only because of the lower cost and the shorter time element involved in their use, but because of the growing inaccessibility of high alloy steels.

Speed Treat is saving money for scores of die and mold shops as well as producers of die shoes, grinding wheel discs for backing up abrasives, motor generator housings, abrasive blast cleaning equipment and many others. Get the complete facts in "The Story of *Speed Treat*" sent on request.

You can change, repair or rebuild molds and dies of *Speed Case* or *Speed Treat* by welding. While other electrodes can be used successfully, *Speed Case* and *Speed Treat* rods are particularly recommended. A bulletin explains the technique, step by step.

A plastics mold gouged out by mistake, in machining, is shown here with the cut partly restored by welding. Repairing and machining was only a fraction of the cost of a new mold. Welding by Bulaw Welding Co. of Chicago, for a Milwaukee firm.

SPEED TREAT STEEL PLATE

FREE MACHINING MEDIUM-CARBON

Quality Controlled *Speed Case* and *Speed Treat* Steels are available in all common plate sizes, hot rolled and cold finished bars and billets.

W. J. HOLLIDAY & CO.

Established 1856

HAMMOND, IND. CHICAGO, ILL. INDIANAPOLIS, IND.

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Beals McCarthy & Rogers
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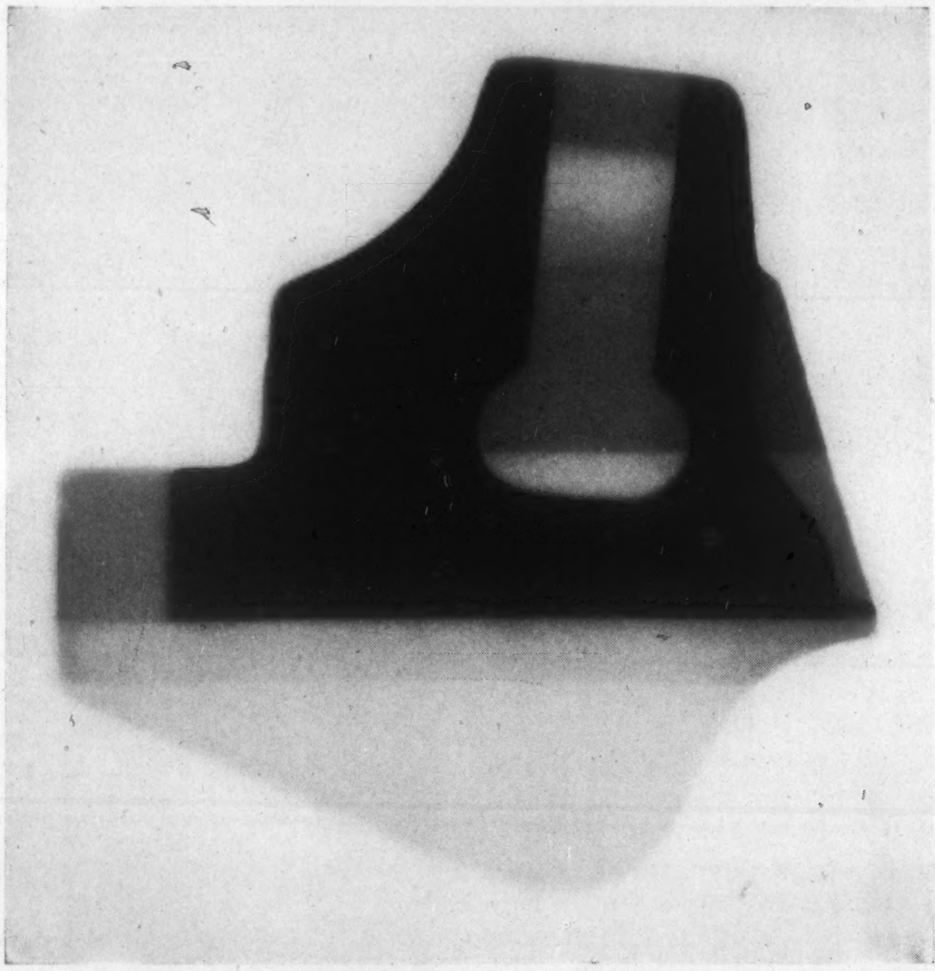
RADIUM



Courtesy Lebanon Steel Foundry, Lebanon, Pa.

Radium Radiograph of casting having various metal thicknesses, the greatest being 3½ inches. Exposure made without any preliminary preparation of specimen for obtaining uniform density.

Radium Radiography will help in obtaining and maintaining uniformly high quality production.

In Radium non-destructive subsurface inspection, specimens of irregular thickness and shape may be easily radiographed.

Exposures are calculated for the greatest metal thickness.

Fogging due to "scattering" is negligible.

Inexpensive film holders, lead intensifying foil and x-ray films are the only accessory items needed for Radium Radiography.

The entire set-up, including Radium, is completely portable.

Radium capsules of various unit strengths in suitable duralumin holders and lead storage containers may be rented at small cost.

Write for details

RADIUM CHEMICAL COMPANY • Inc.

570 Lexington Ave., New York

Chicago: Marshall Field Annex Building

PREVIEW of the

Forty-fourth Annual Convention

of the

American Society for Testing Materials

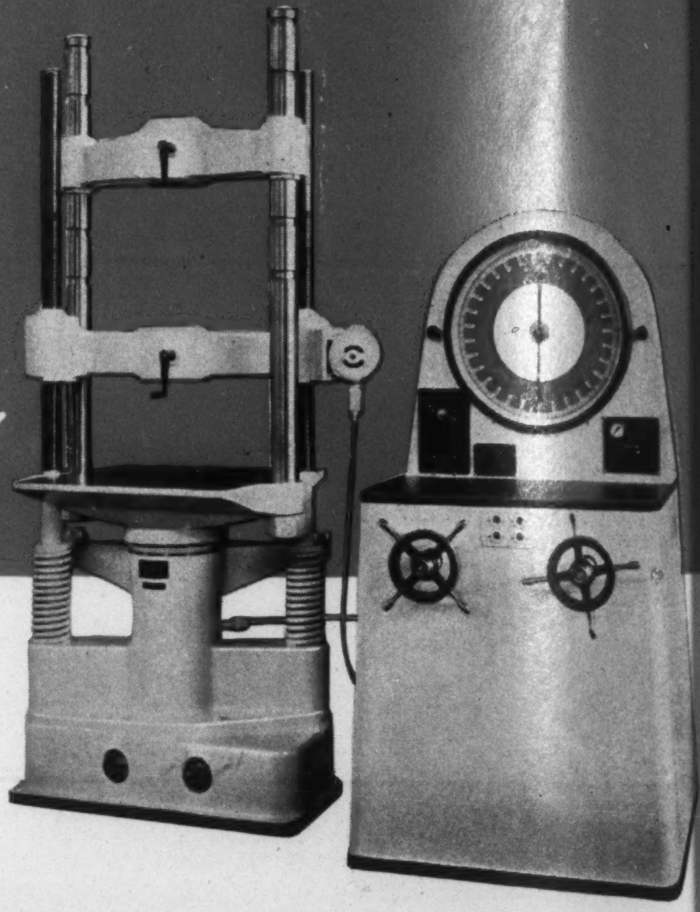
Palmer House, Chicago

June 23 to 27, 1941

INDUSTRY'S LEADING LABORATORIES WILL BE JUST LIKE HOME TO

June's Engineering Graduates from 55 Colleges

because they've been trained on



SOUTHWARK-EMERY Testing Machines are in widespread use throughout the country—in universities and in industry alike. Seventy-eight of these machines are now being used by 55 leading colleges ● Simple to operate, versatile in application, Southwark-Emery testing machines offer you unsurpassed accuracy and sensitivity ● Products of research, Southwark-Emery testing machines incorporate the most recent and most important developments in physical testing equipment ● Baldwin Southwark Division, The Baldwin Locomotive Works, Philadelphia; Pacific Coast Representative, The Pelton Water Wheel Co., San Francisco.

Baldwin Southwark

DIVISION OF THE BALDWIN LOCOMOTIVE WORKS
PHILADELPHIA

BLW
THE BALDWIN GROUP

Introduction

According to its established custom to hold an annual meeting away from Atlantic City periodically, the executive committee has arranged that the 44th annual convention of the American Society for Testing Materials be held at the Palmer House in Chicago, June 23 to 27. An exhibit of testing apparatus and instruments is held by the society periodically and one has been scheduled for this year.

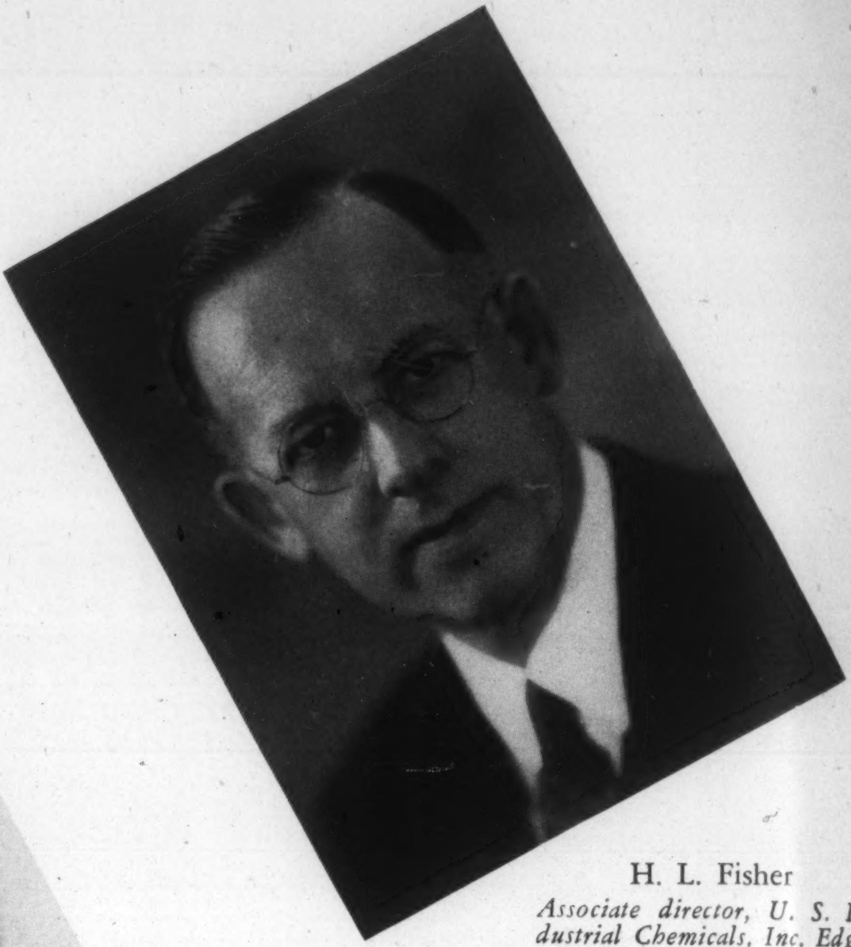
All day Monday, June 23, is reserved for committee meetings, the regular technical program starting on Tuesday, June 24. The usually excellent program has been arranged, covering all the many activities of the society. On the following pages, the tentative schedule of papers for the sessions of interest to metallurgical engineers and men in the metal and alloy industries is published. Two separate technical sessions are necessary to include papers and reports on non-ferrous metals. Some of the other important sessions cover plastics, steel and effect of temperature, fatigue of metals, and corrosion of iron and steel.

The Edgar Marburg Lecture, always a highlight, will be delivered by Dr. H. L. Fisher, associate director, research laboratory, U. S. Industrial Chemicals, Inc., on the subject—"Natural and Synthetic Rubbers."

The Charles B. Dudley Medal for 1941 will be awarded to C. W. MacGregor, associate professor of applied mechanics, M. I. T., for his paper on—"The Tension Test"—at the 1940 annual convention.

The arrangements for this convention are in the hands of a large committee with H. H. Morgan, R. W. Hunt & Co., honorary chairman and E. R. Young, Climax Molybdenum Co., chairman.

Wm. M. Barr
Chief chemical and metallurgical engineer, Union Pacific Railroad Co. A. S. T. M. president, 1940-1941.



H. L. Fisher
Associate director, U. S. Industrial Chemicals, Inc. Edgar Marburg Lecturer for 1941.

Tentative Technical Program

C. W. MacGregor
Assoc. professor of applied mechanics, M. I. T. Charles B. Dudley Medalist for 1941.

Tuesday, June 24

Morning

Formal Opening of the Forty-fourth Annual Meeting, by President W. M. Barr.

Welcome by Chicago Committee on Arrangements, H. H. Morgan, Honorary Chairman; E. R. Young, Chairman.

Report of Committee E-9 on Research.

Report of Committee E-10 on Standards.

Address—"Mobilizing Materials for Defense," by J. H. Van Deventer, President and Editor, *The Iron Age.*

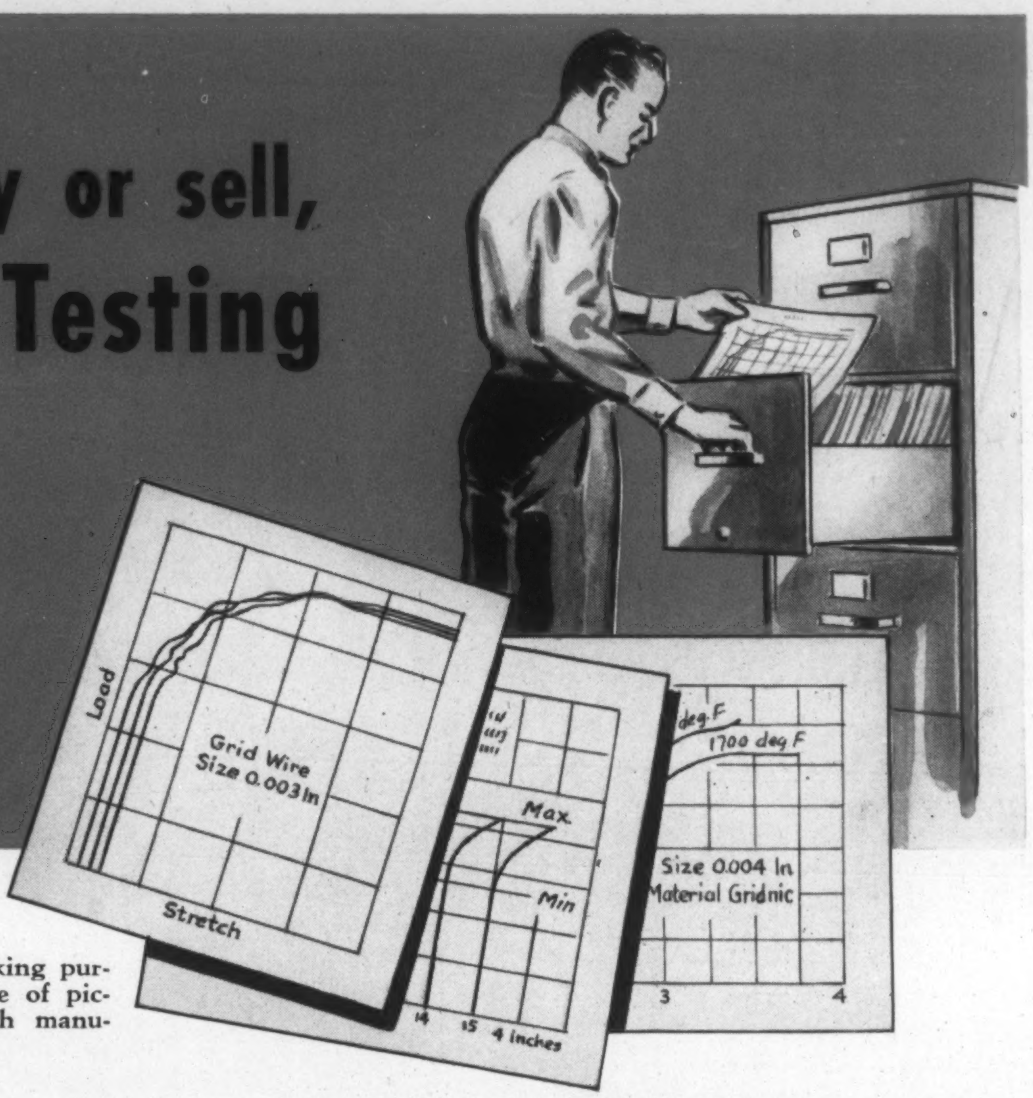
Annual Report of the Executive Committee, by C. L. Warwick, Secretary-Treasurer.

Recognition of Forty-year Members.

Introduction of Newly Elected Officers.

Presidential Address—*"Speed, Spe-*

Whether you buy or sell, "Picturized" Testing of your wire pays big dividends



*Scott Testers render constant service for checking purchases and manufacture, while the resulting file of picturized charts is an invaluable record to both manufacturer and purchaser.

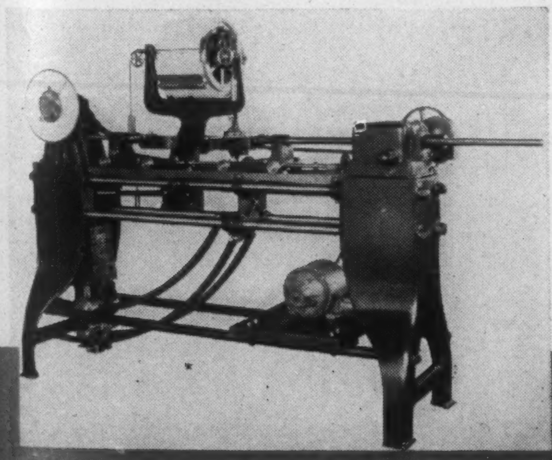
Scott Testers—4 gr. to 2,000 lb.

*Scott Tester methods of testing and recording are standard the world over for wire and strip metal. These machines test wires from 4 gr. to 2,000 lb., recording the result on autographic charts which are extremely simple to read, with little or no conversion.

At the right is shown Model J-5, standard for the tire wire industry. It has cylindrical type recorder which magnifies stress strain curve in ratios as high as 20 to 1. Clearly shows elastic limit, yield point, ultimate elongation and tensile strength. Various capacities, up to 1,000 lb.

Machine at left is Model Q-7, designed for heavier testing up to 2,000 lbs., but operating on the same principles as J-5.

For lighter testing, our exclusive Incline-plane machines are available, permitting tests of the very finest wires. On this machine adjustability of sample length allows wires of high or low strength to be tested on a six-inch wide chart.



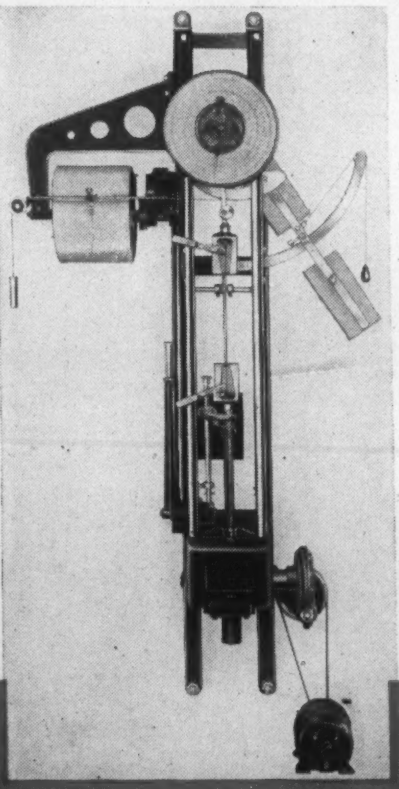
Model Q-7. Heavy duty wire tester with capacity 2,000 lb.

Scott Testers are also adaptable to Cartridge Assembly Testing.

HENRY L. SCOTT CO.
Providence, R. I.

SCOTT TESTERS

*Registered Trademark



Model J-5. For tire wire, spring wire, etc. Capacities from 0 to 1,000 lb.

multiple metallurgical Specimens

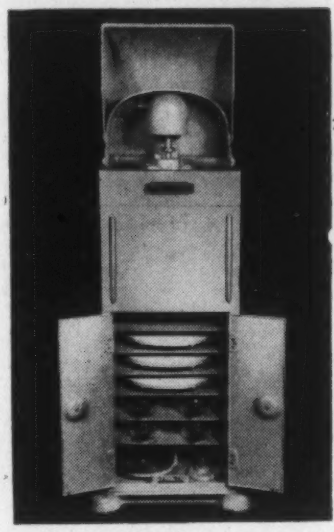
SIMULTANEOUSLY GROUND-POLISHED with STONES!

This Jarrett Polishing Machine will produce up to 180 highly finished, flat metallurgical specimens in a few minutes—and with few operations . . . The use of stone laps assures specimen uniformity of exceptionally high quality, and the design of the machine itself requires an operating technique so simplified that even inexperienced operators are able to turn out large quantities of specimens efficiently.

Write today for our catalog which fully describes this improved specimen polishing machine.

TRACY C. JARRETT

P. O. BOX 3155 CATONSVILLE, MD.



10 INTERCHANGEABLE THERMOCOUPLES GIVE "Specialized" ADAPTATION TO THIS SURFACE TEMPERATURE PYROMETER

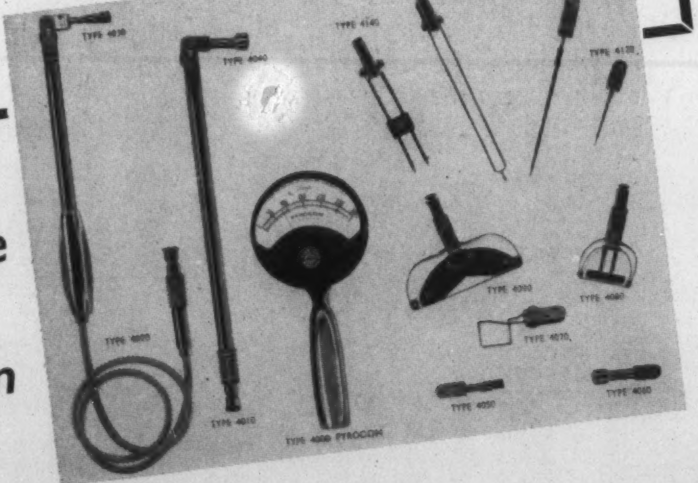
Supplied with ten different thermocouples—instantly changeable without recalibration of the pyrometer—the improved Alnor Pyrocon does the work which formerly required several separate instruments. . . . Reliably accurate temperature readings of *any* surface—flat, curved, stationary or revolving—can be obtained in a few seconds by this convenient and versatile instrument. . . . Its applications include temperature determination of metallic surfaces, hard, clean or coated; heat of bearings; soft molten metals; pre-heat temperatures for welding, etc.

Write for Bulletin 3511

Illinois Testing Laboratories Inc.

Dont Guess Know

425 N. LaSalle St., Chicago, Illinois



cifications, and Safety," President W. M. Barr, chief chemical and metallurgical engineer, Union Pacific Railroad Co.

Afternoon

JOINT SESSION WITH WESTERN SOCIETY OF ENGINEERS, ON SUBWAYS AND SUPERHIGHWAYS

Evening

NON-FERROUS METALS

Report of Committee B-2 on Non-Ferrous Metals and Alloys.

"The Properties of Certain Lead-Bearing Alloys," by Albert J. Phillips, A. A. Smith, Jr., and Paul A. Beck, American Smelting & Refining Co.

Report of Committee B-4 on Electrical - Heating, Electrical - Resistance and Electric-Furnace Alloys.

"Method for Determining the Density of Fine Wire," by Stanton Umbreit, RCA Mfg. Co., Inc.

Report of Committee B-1 on Copper and Copper-Alloy Wires for Electrical Conductors.

"Comparative Value of Arsenic, Antimony and Phosphorus in Preventing Dezincification," by W. Lynes, Revere Copper & Brass, Inc.

"The Tensile Properties of Some Copper Alloys," by Cyril Stanley Smith and R. W. Van Wagner, American Brass Co.

"Fatigue Tests on Some Copper Alloys," by A. R. Anderson and Cyril Stanley Smith, American Brass Co.

Wednesday, June 25

Morning

NON-FERROUS METALS (SECOND SESSION) CORROSION OF NON-FERROUS METALS

Report of Committee B-6 on Die-Cast Metals and Alloys.

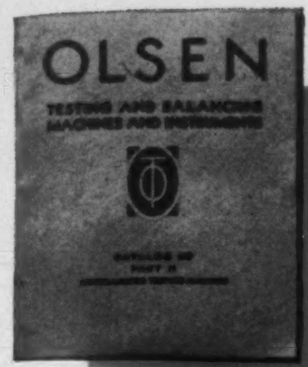
Papers Appended:

"Finishes for Aluminum Die Casting," by A. E. Keskulla and Junius D. Edwards, Aluminum Co. of America.

"Finishing Magnesium Die Castings," by H. W. Schmidt, The Dow Chemical Co.

"The Finishing of Zinc Alloy Die Castings," by E. A. Anderson, The New Jersey Zinc Co. (of Pa.)

Report of Committee B-7 on Light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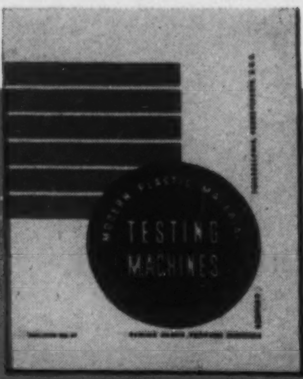
TESTING AND BALANCING MACHINES AND INSTRUMENTS

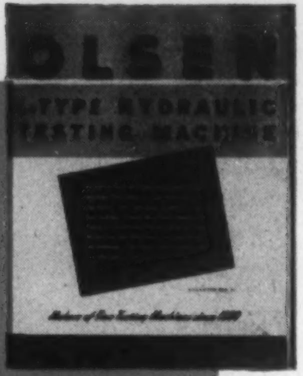
No. 50-H TESTING & BALANCING MACHINES & INSTRUMENTS


TESTING MACHINES

No. 17 PLASTIC MATERIAL TESTING MACHINES

OLSEN PROVING RINGS

No. 16 PROVING RINGS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L-TYPE HYDRAULIC TESTING MACHINES

No. 20 L-TYPE HYDRAULIC TESTING MACHINES

here's part of our story!

Fourteen Olsen Catalogs, yours for the asking. Complete and detailed, they are made for easy reference. (A new bulletin in preparation covering the Olsen Impact Tester is not shown.)

These bulletins tell only part of the Tinius Olsen story. Behind them is sixty years of specialization in the manufacture of fine testing equipment —and thousands of Olsen machines in operation all over the country, in industrial plants, laboratories, and colleges.

Before you buy any testing equipment be sure to investigate Tinius Olsen — for diversity, quality, and accuracy. Write today for any or all of the bulletins mentioned.

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500 N. TWELFTH STREET
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No. 50-L UNIVERSAL TESTING MACHINES

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Strain Gauges
Extensometers

No. 21 STRAIN GAUGES & EXTENSOMETERS

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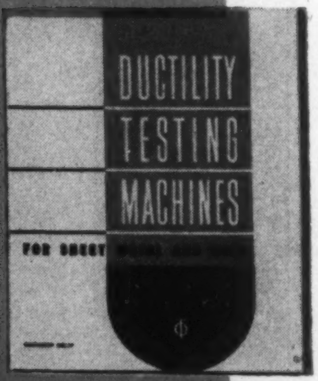
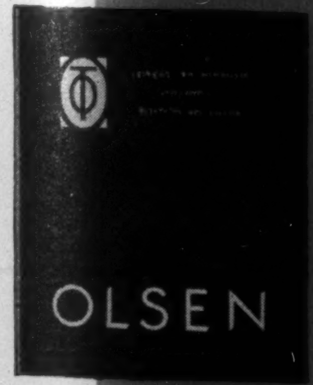
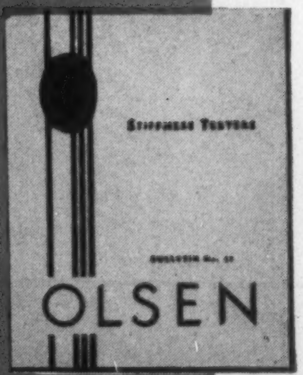
No. 18 ELECTRONIC HIGH MAGNIFICATION RECORDER


DUCTILITY
TESTING
MACHINES

No. 15 DUCTILITY TESTING MACHINES



No. 50-C CEMENT & ROAD MATERIALS TESTERS


STIFFNESS TESTERS
OLSEN

No. 11 STIFFNESS TESTERS

No. 1 HARDNESS TESTING EQUIPMENT

Proving every day that the value of testing depends on the quality of the testing equipment.

◀ No. 14 E-O STATIC & DYNAMIC BALANCERS

OLSEN
Static and Dynamic
BALANCING MACHINES

No. 19 STATIC & DYNAMIC BALANCING MACHINES ▶

Metals and Alloys, Cast and Wrought.

Report of Committee B-8 on Electrodeposited Metallic Coatings.

Report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys.

Report of Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

"Influence of Combined External and Internal Stresses on Tendency to Stress Corrosion Crack of Cartridge Brass," by Harry P. Croft, Chase Brass and Copper Co.

"Mercury Cracking Test, Procedure and Control," by H. Rosenthal and A. L. Jamieson, Frankford Arsenal.

Afternoon

MARBURG LECTURE—DUDLEY MEDAL AWARD

Sixteenth Edgar Marburg Lecture: *"Natural and Synthetic Rubbers,"* by H. L. Fisher, Associate Director, U. S. Industrial Chemicals, Inc.

Award of Charles B. Dudley Medal. To C. W. MacGregor, Associate Professor of Applied Mechanics, Massachusetts Institute of Technology.

Cocktail Reception

Immediately following the Tenth Session, the Chicago Committee on Arrangements will be hosts at a cocktail reception when all members, guests, and ladies will have an opportunity to meet the outgoing and incoming officers of the Society.

Thursday, June 26

STEEL, EFFECT OF TEMPERATURE

Report of Joint Committee on Definitions of Terms Relating to Heat Treatment.

Report of Committee E-4 on Metallography.

Report of Joint Research Committee on Effect of Temperature on the Properties of Metals.

Paper Appended:

> *"Study of Impact Resistance and Tensile Properties of Metals at Subatmospheric Temperatures,"* by H. W. Gillett, H. W. Russell, S. L. Hoyt, and H. C. Cross, Battelle Memorial Institute.

"The Effect of Carbide Spheroidization upon the Creep Strength of Carbon-Molybdenum Steel," by S. H. Weaver, General Electric Co.

"The Fabrication of Carbon-Molybdenum Piping for High-Temperature Service," by R. W. Emerson, Pittsburgh Piping and Equipment Co.

Report of Committee A-1 on Steel.

Report of Sectional Committee B36 on Standardization of Dimensions and Materials of Wrought-Iron and Wrought-Steel Pipe and Tubing.

"Compression and Tension Tests of Structural Alloys," by Bruce Johnston, Lehigh University, and Francis Opila, Baldwin-Southwark Corp.

Report of Committee A-9 on Ferro-Alloys.

Report of Committee A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys.

"The Stress-Strain Characteristics of Cold-Rolled Austenitic Stainless Steels in Compression as Determined by the Cylinder Test Method," by Russell Franks and W. O. Binder, Union Carbide and Carbon Research Labs., Inc.

"A New Free-Machining Addition for Stainless Steels," by H. Pray, R. S. Peoples, and F. W. Fink, Battelle Memorial Institute.

GAMMA RAY RADIOGRAPHY

detects blowholes, gas pockets, non-metallic substances, cracks, etc.

Radium is NECESSARY For Greatest Metal Thickness

Radium is BEST For Weld Inspection

Radium is PORTABLE

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Literature and Details on Request

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Edward Bausch . . . . . Microscope Maker

WHILE Pasteur and his contemporaries were fighting the combined forces of superstition and disease to lay the foundations for modern bacteriology, another young man was designing a microscope that would help immeasurably in spreading the benefits of science to all mankind.

While Pasteur was proving that heating would destroy the organisms that were making French wines turn bitter, and perfecting the pasteurizing process that makes his name immortal, in America, Edward Bausch was computing his own objectives, grinding his lenses and fitting the parts for the first Bausch & Lomb Microscope.

While Pasteur was proving his procedure for the cure of rabies by saving the life of the little Alsatian peasant, Joseph Meister, Edward Bausch was working day and night to demonstrate his belief that quality microscopes could be made in quantities and at such prices as to bring them within the reach of all students and research workers.

Today—you'll find Bausch & Lomb Microscopes in all the far corners of the world. Scientists in education, medicine and industry alike, know that no better optical instruments can be had than those bearing the Bausch & Lomb Trademark.

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AN AMERICAN SCIENTIFIC INSTITUTION PRODUCING OPTICAL GLASS AND INSTRUMENTS FOR NATIONAL DEFENSE, EDUCATION, RESEARCH, INDUSTRY AND EYESIGHT CORRECTION

Afternoon

METHODS OF TESTING

Report of Committee E-8 on Nomenclature and Definitions.

Report of Committee E-2 on Spectrographic Analysis.

Report of Committee E-3 on Chemical Analysis of Metals.

Report of Committee E-7 on Radiographic Testing.

Report of Committee E-1 on Methods of Testing.

Paper Appended:

"Methods of Testing Volumetric Glassware," by J. J. Moran, Kimble Glass Co.

"Statistical Theory of the Effect of Dimensions and of Method of Loading upon the Modulus of Rupture of Beams," by John Tucker, Jr., National Bureau of Standards.

Address — *"The Electron Microscope and Its Uses,"* by R. Bowling Barnes, director, physics division, American Cyanamid Co.

Evening

FATIGUE OF METALS, CORROSION OF IRON AND STEEL

Report of Research Committee on Fatigue of Metals.

"The Effect of Shot Blasting and Its Bearing on Fatigue," by W. M. Murray and J. M. Lessells, Massachusetts Institute of Technology.

"Fatigue Comparison of 7-in. Diameter Solid and Tubular Axles," by O. J. Horger and T. V. Buckwalter, Timken Roller Bearing Co.

"Pitting and Its Effect on the Fatigue Limit of Steels Corroded Under Various Conditions," by D. J. McAdam, Jr., and G. W. Geil, National Bureau of Standards.

"A New High-Temperature Fatigue Machine," by W. P. Welch and W. A. Wilson, Westinghouse Electric and Mfg. Co.

"Testing Material in the Resonance Range," by R. K. Bernhard, The Pennsylvania State College.

"An Accelerated Atmospheric Corrosion Test," by H. Pray, Battelle Memorial Institute, and J. L. Gregg, Bethelehem Steel Co.

"An Equation Representing the Rate of Development of Rust on Galvanized Iron Sheets as Estimated by the A.S.T.M. Test," by J. B. Austin, United States Steel Corp.

Friday, June 27

Morning

IRON

Report of Committee A-6 on Magnetic Properties.

"Measurement of Core Loss and A-C. Permeability with the 25-cm. Epstein Frame," by S. L. Burgwin, Westinghouse Research Laboratories.

Informal Report of Sectional Committee A21 on Specifications for Cast-Iron Pipe and Fittings.

Report of Committee A-7 on Malleable Iron Castings.

Report of Committee A-3 on Cast Iron.

"The Strain Hardening of Gray Cast Iron," by John Sanford Peck, College of the City of New York.

"Fatigue and Static Load Tests of a High-Strength Cast Iron at Elevated Temperatures," by W. Leighton Collins and James O. Smith, University of Illinois.

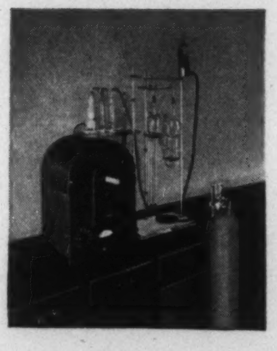
"Young's Modulus of Elasticity and Some Related Properties of Graphitic Materials," by H. A. Schwartz and C. H. Junge, National Malleable and Steel Castings Co.

"ROCKWELL" Motorized HARDNESS TESTER

Some Special Requirements call for a Motorized Model

WILSON
MECHANICAL INSTRUMENT CO., INC.
Concord Avenue, N. Y. City

MODERN ANALYSIS


Carbon Determinator

CARBON & SULPHUR DETERMINATIONS
Accurate carbon determinations made in two minutes of all metals with Carbon Determinator. Secure accurate sulphur determinations in three minutes with Sulphur Determinator. Cast specimens may be used.

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Save time, fuel and materials with rapid control analysis.

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AT BOOTH 55

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presents exhibit of:

1 Eastman Industrial X-ray Film—new-type x-ray film especially designed for industrial radiography.

2 Interesting representative radiographs made on Eastman Industrial X-ray Film.

3 Complete line of Eastman accessories and chemicals for use in exposure and processing of x-ray films.

Technical experts and members of the staff of Kodak Research Laboratories will be in charge of the Kodak booth at the convention of the American Society for Testing Materials, Chicago, Ill., week of June 23. You are invited to discuss your specific radiographic and photographic problems with them.

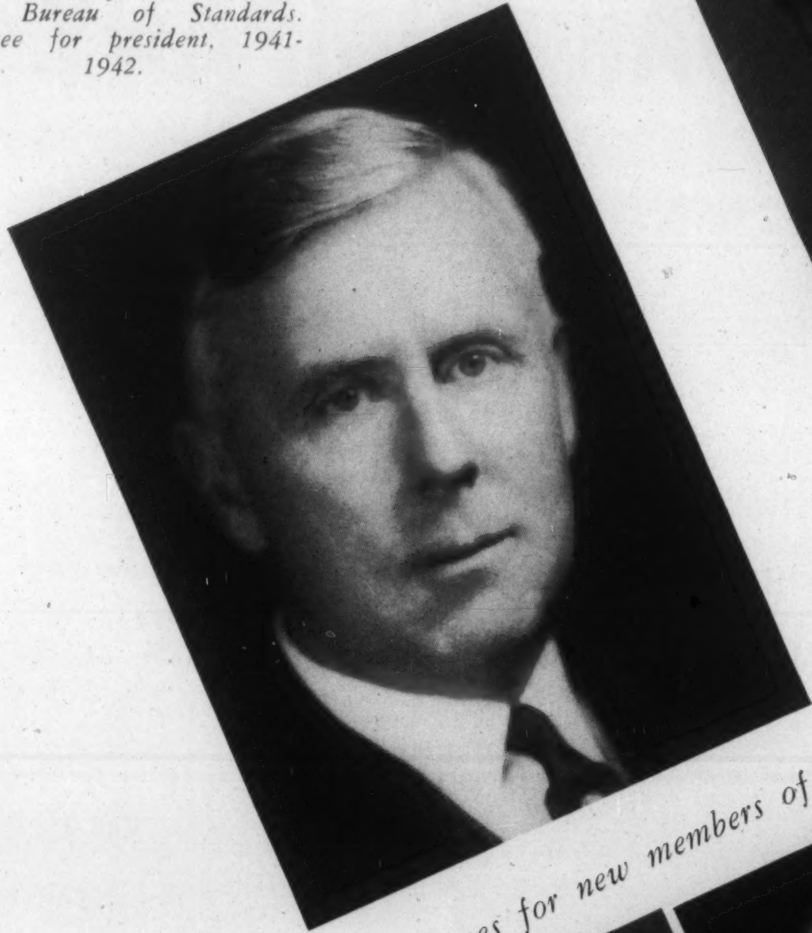
EASTMAN KODAK COMPANY

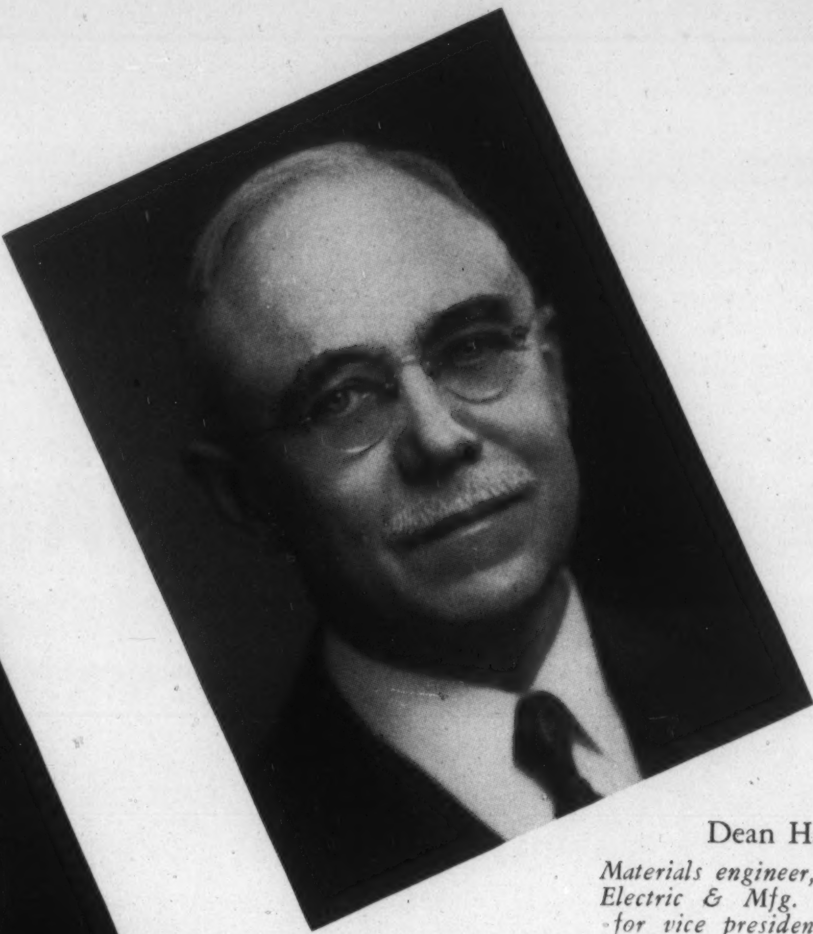
ROCHESTER, N. Y.

World's largest manufacturer of radiographic and photographic materials

G. E. F. Lundell

Chief, chemistry division, National Bureau of Standards. Nominee for president, 1941-1942.

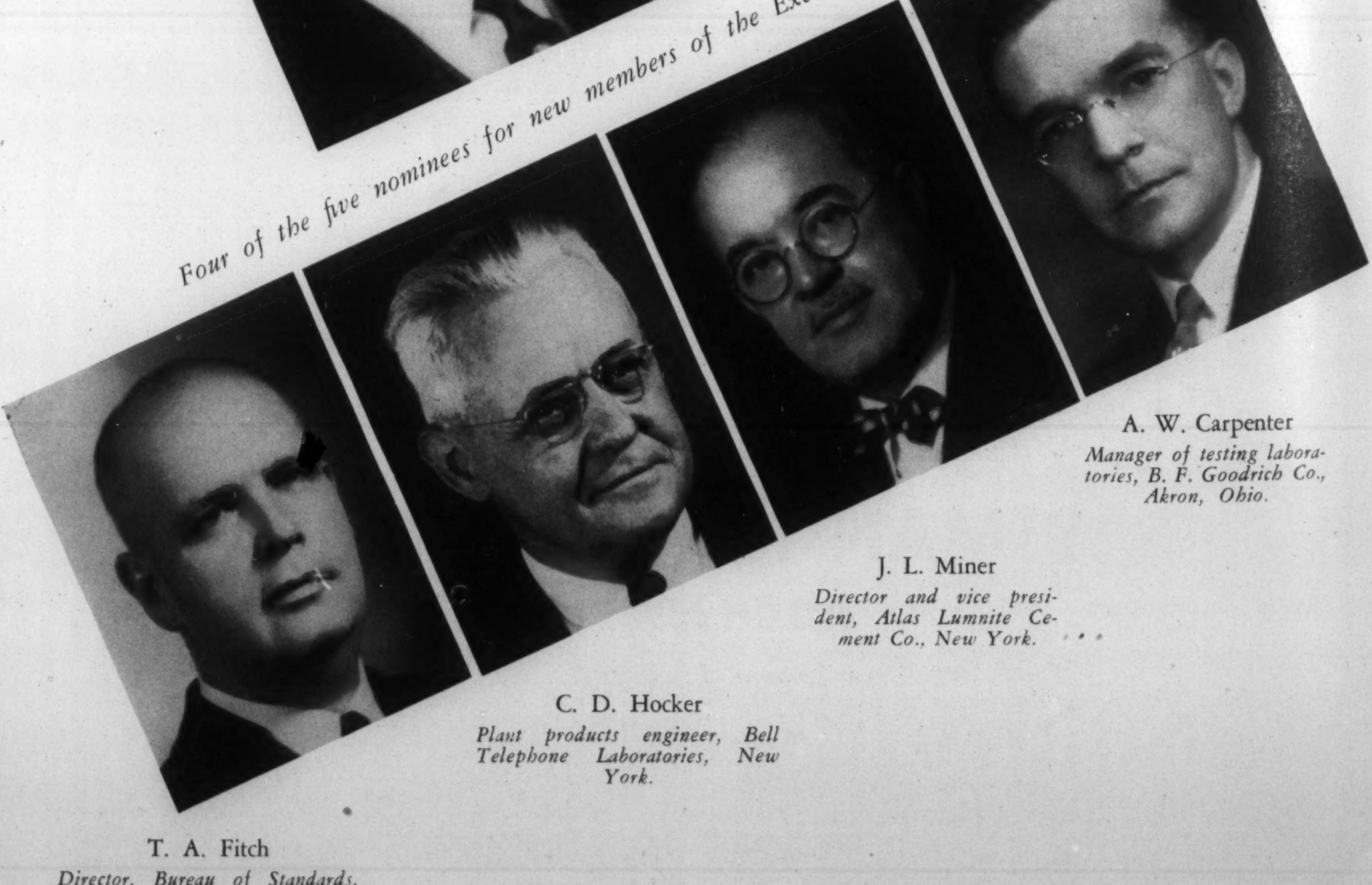




Dean Harvey

Materials engineer, Westinghouse Electric & Mfg. Co. Nominee for vice president, 1941-1943.

Four of the five nominees for new members of the Executive Committee.



A. W. Carpenter

Manager of testing laboratories, B. F. Goodrich Co., Akron, Ohio.

J. L. Miner

Director and vice president, Atlas Lumnite Cement Co., New York.

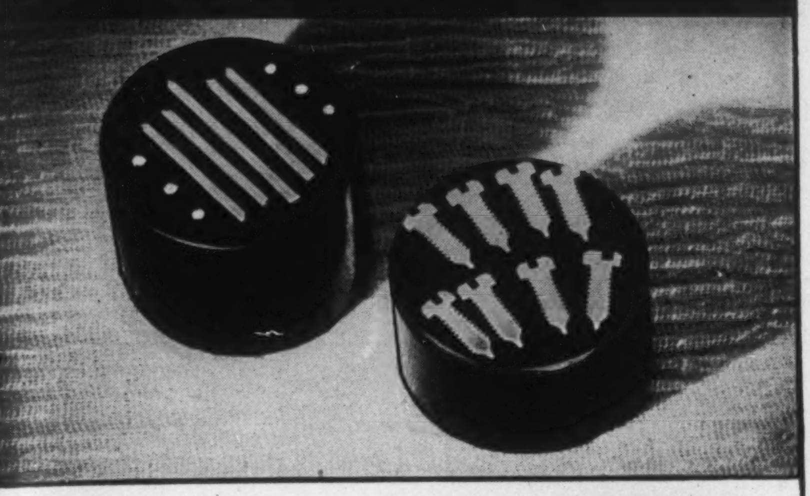
C. D. Hocker

Plant products engineer, Bell Telephone Laboratories, New York.

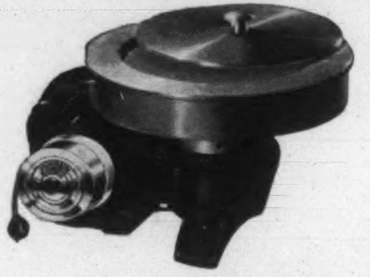
T. A. Fitch

Director, Bureau of Standards, Los Angeles, Cal.

IN METALLURGY . . .



AB SPECIMEN PREPARATION EQUIPMENT is USED EVERYWHERE



Low Speed Polisher

For extreme accuracy in flatness use the AB LEAD DISC ASSEMBLY, retaining graphite and inclusions. Save time with the AB MECHANICAL HOLDER and polish 1 to 6 specimens simultaneously.

THE AB SPECIMEN CUTTER ASSEMBLY offers safe and cool cutting of specimens. Perfect radial and axial alignment, efficient design and craftsmanship make this cutter an indispensable tool for the Metallurgist. The Sludge trap drawer removes grit and waste from the cooling fluid and prevents clogging of drains.

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ASK FOR YOUR COPY OF "THE METAL ANALYST"

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OPTICAL INSTRUMENTS • METALLURGICAL APPARATUS
228 NORTH LA SALLE ST. • • CHICAGO ILL.

NEW GLASS-ELECTRODE PH INDICATOR—$160

Although simplified and stripped to essentials for low cost and easy operation, L&N's new Glass-Electrode pH Indicator measures within a limit of error of ±0.1 pH. It includes everything necessary for measuring pH, and is also adaptable to titrations.

Speed and convenience are inherent. Adjustments take but a moment, and measurements are made by pouring the sample into the beaker and reading pH directly from the meter scale.

Outstanding advantages include:

1. Full accuracy in atmospheres of 95% relative humidity up to 85 F.
2. Manual temperature compensator eliminates computations, saving time and preventing errors.
3. Instrument is adequately shielded from electrical disturbances.
4. The double range, covering 0-8 and 6-14 pH, provides a convenient overlap of 2 pH . . . a desirable feature for titrations.
5. The scale is longer than in any comparable pH indicator.
6. The mahogany case is built to stand up under severe use. Wood and finish are unaffected by high humidity.
7. Batteries are separated from the electrical circuits to avoid corrosion from spent batteries.
8. A whole end of the box swings out, leaving the electrodes and sample holder easily accessible.
9. Glass electrode is adequately shielded against electrical effects.
10. Factory sealed and filled electrodes are highly stable.
11. The sample cup is a standard 50 ml. beaker.
12. Fifteen-inch leads permit electrodes to be used external to the case, for titration as well as pH.
13. Light, well-balanced, and easily portable, the instrument case carries everything necessary for measurements.
14. Only 3 simple preliminary adjustments are necessary.
15. Maintenance is negligible, consisting of adding KCl to the salt bridge every 6 or 8 weeks, cleaning the electrodes occasionally, and replacing batteries at infrequent intervals.

7662-A1 GLASS-ELECTRODE pH INDICATOR ASSEMBLY

Ranges	0 to 8 pH, and 6 to 14 pH
Limit of Error	±0.1 pH, exclusive of any error in the buffer solution
Temperature Compensator	Range, 0 to 50 C
Price	$160.00

See this Indicator at ASTM Exhibit—Booth 59, or write for Catalog E-96 (2)

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LEEDS & NORTHRUP
MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES
Jrl Ad E-96(17)

The Exhibit

The sixth exhibition of testing apparatus and instruments, sponsored by the society, will be held in the Palmer House during the convention. Several new instruments and apparatus related to testing will be on display. Since the first exhibit in Chicago in 1931, it has become a feature of the conventions held in odd numbered years.

A list of the exhibiting companies follows:

Atlas Electric Devices Co., Inc. Chicago

The basis of a two-booth display being featured by this company will be the three types of Atlasometers: Fade-Ometer, Launder-Ometer, and Weather-Ometer. Various applications will be demonstrated.

Baldwin-Southwark Corp. Philadelphia

Outstanding attraction is expected to be the company's new SR-4 bonded metalectric strain gages. Capable of reading static strains down to 15 psi. in steel and frequencies to over 30,000 cycles per second, the gages were first introduced last year. Recent improvements include the development of a temperature compensated gage for application to curved surfaces and an improved strain rosette for two-dimensional stress analysis.

Christian Becker, Inc. New York

This display will comprise a full line of Christian Becker analytical balances and torsion laboratory scales. Included among these balances will be the popular dial reading Chainomatic analytical balances, micro balances, magnetically damped balances, keyboard balances, etc. A feature of particular interest will be the projection reading analytical balance.

Torsion balances for laboratory work in the dairy, drug, chemical, and textile industries will be on exhibit.

W. H. & L. D. Betz Philadelphia

This company will exhibit the new Straub type degassing condenser for removal of non-condensable gases from steam for conductivity determinations. They will also show water testing equipment for plant and laboratory control tests, including the new "M" Test Kit, a complete portable water testing laboratory in itself. A new Solu-bridge for conductivity determinations of both condensate and boiler water will also be exhibited.

Brabender Corp. Rochelle Park, N. J.

The Plastograph (Recording Plastometer) which measures consistency over a wide range of pliable material, has been applied in research and plant control on such materials as: Unvulcanized rubber, celluloid, rayon, activated carbon, paints, fertilizer, starch etc. The Brabender semi-automatic moisture tester will be featured also. The pressure thermostat, a central thermostatic unit capable of feeding an entire laboratory requirement of temperature controlled water baths is to be on display. Also the Brabender viscograph, capable of measuring and recording viscosities at a constant rate increase of temperature, from room temperature up to 150 C.

Adolph I. Buehler Chicago

Various types of optical instruments for testing and research and other equipment including a selection from the following list: measuring, polarizing, and Brinell microscopes; metallographs; spectrographs; titrators; carbonmeters; cutters; grinders; polishing apparatus will be displayed. Among the features will be the AB micro hardness tester.

Canadian Radium & Uranium Corp.
New York

Great progress has been made in recent years in the application of radiography to industrial needs. The Canadian Radium & Uranium Corp. represents Eldorado Gold Mines Ltd., Toronto, the world's largest producers of radium and the only producer in the Western hemisphere. This high-purity Canadian radium is now offered the metal industry in approved containers for gamma-ray radiography.

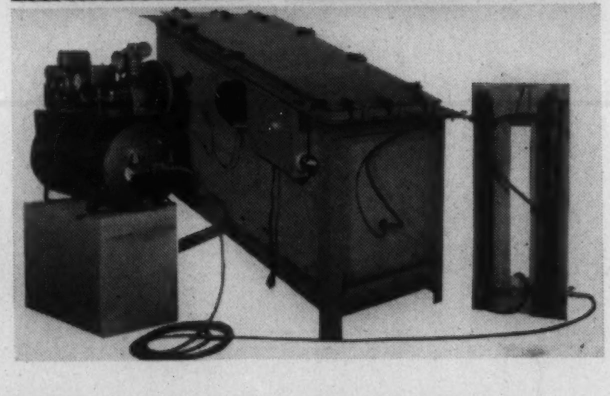
Central Scientific Co. Chicago

This company will feature a number of new developments in the laboratory field: The unique Cenco-Meinzer sieve shaker; a new high-torque cone-drive motor stirrer; the Cenco-Menzel autoclave for accelerated soundness tests on cement; the Cenco grating spectrograph for qualitative and quantitative analysis; a new magnetic damping device for analytical balances; a hammer-type pulverizing mill; and many other developments of interest in the testing, analysis, and research on engineering materials.

Coleman Electric Co. Maywood, Ill.

This display will consist of a complete line of glass electrode pH electrometers, ranging from the low cost and especially rugged industrial tester to the high precision laboratory instruments. In addition to pH equipment, Coleman will exhibit two models of spectrophotometers. including the newly introduced Universal spectrophotometer with its ultraviolet illuminator

ALBERENE STONE
SALT
SPRAY
BOXES



IMMEDIATELY AVAILABLE...FOR CORROSION TESTS

The tremendous increase in the manufacture of metal parts which must be subjected to salt spray corrosion tests has caused a heavy demand for salt spray boxes. The performance of Alberene Stone boxes during the past ten to fifteen years has established both their efficiency and their durability. » » » We are prepared to furnish *promptly* fully-equipped salt spray boxes, as shown in the upper photo; also complete units, shown in the lower photo, built to the standard program Army-Navy-Aeronautical specifications for salt spray corrosion tests. We will also make boxes to individual specifications. Please address inquiries to 419 Fourth Avenue, N. Y.

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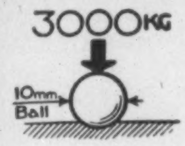
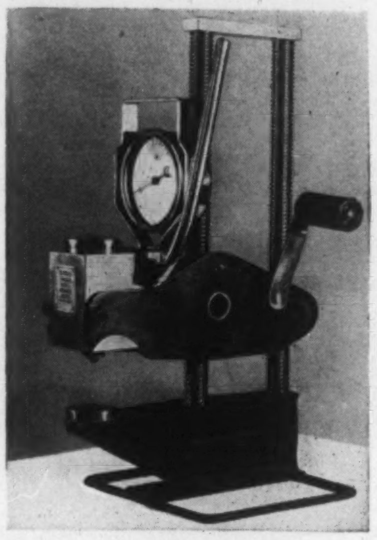


A REAL BRINELL TEST

is what you get with the

KING PORTABLE Brinell Hardness Tester



Puts an actual load of 3000 kg. on a 10mm ball. Makes a real Brinell test.

Depth of throat 4".
Height of gap 10".
Weighs only 26 lbs.

Test head removable for testing pieces of any size, in any position.

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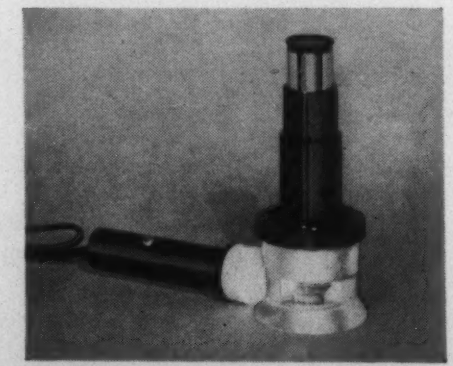
PIKE

THE *New*
FLASH-O-LENS
(REG. U. S. PAT. OFF.)

The Instrument Of A Thousand Uses

Routine inspection of product and process equipment is a universal practice in industry today. To meet this need we have a new Bausch & Lomb portable microscope which can be attached to any "FLASH-O-LENS" which you may now be using. In the body tube is a graduated scale reading directly to thousandths of an inch. Magnification up to 40X is available, and REMEMBER you have the added essential virtue of illumination either by dry cells or electric current "FLASH-O-LENS" is of greatest value even in the darkest corner of the shop. Send for illustrated catalogue.



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Please send me catalog and full information on your illuminated lenses.
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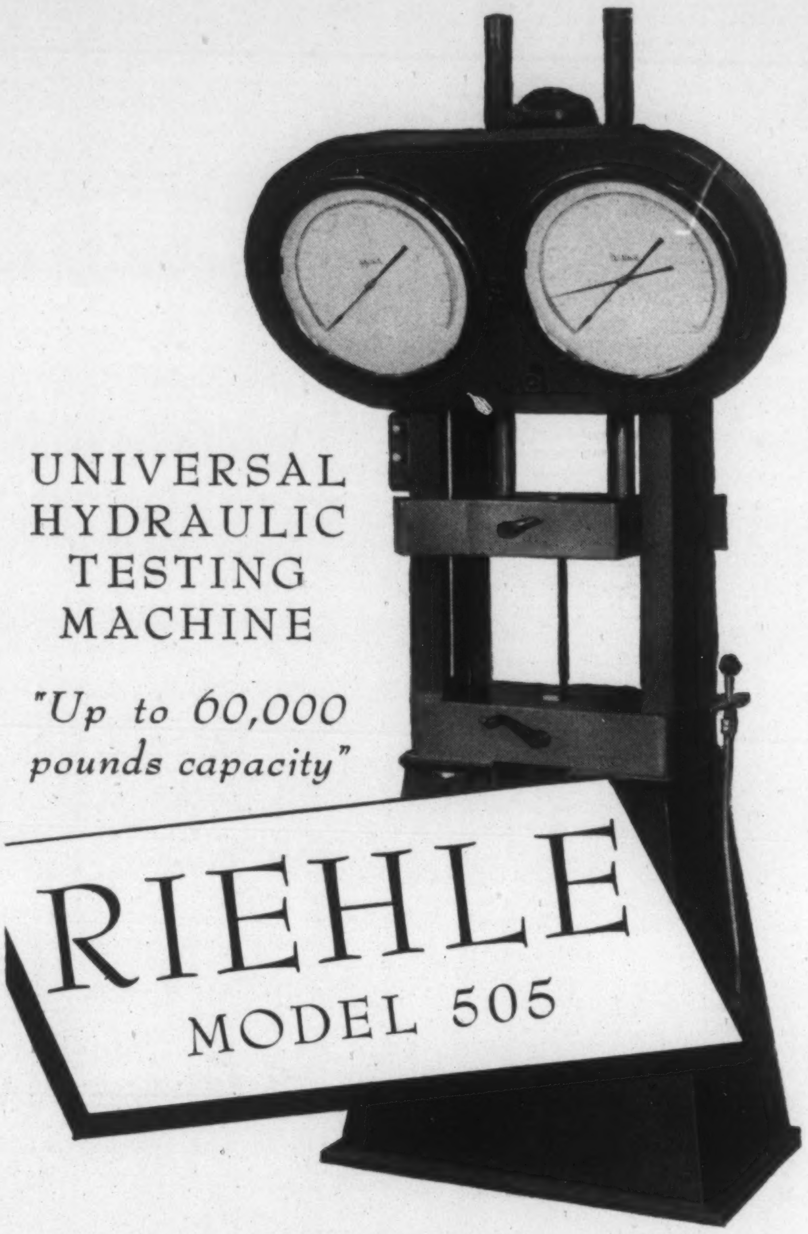


UNIVERSAL HYDRAULIC TESTING MACHINE

"Up to 60,000 pounds capacity"

RIEHLE
MODEL 505

- ★ *Model 505 is the most accurate and reliable machine in the low priced bracket today.*
- ★ Rubber mounted dial panel with inclination adjustable to suit the height of the operator in a sitting or standing position.
- ★ Extensometer—specimen—load indicator and speed control scale can be observed by one operator without changing position.
- ★ Two motor drives—one for hydraulic loading and a second one for fast vertical adjustment of gripping head and table.
- ★ Spherically suspended gripping head and table assuring consistent accuracy even with loads applied off-center.
- ★ Highest quality, high pressure piston pump for lifetime service and accurate speed control.
- ★ Testing speeds marked on large scale in inches per minute.
- ★ Capacities available include 10,000, 20,000, 30,000, 40,000 and 60,000 lbs. Popular sizes 40,000 and 60,000 lbs. are stocked to enable *delivery on short notice.*

RIEHLE TESTING MACHINES
Division of American Machine and Metals, Inc.
East Moline, Ill.

ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS

FILL IN — MAIL AT ONCE!

RIEHLE TESTING MACHINE DIVISION
403 Riehle St., East Moline, Ill.

YES! Without obligation send me DETAILS on Riehle Universal Hydraulic Testing Machines. Also literature on Riehle Impact Tester.

Name ____________
Address ____________ State ______
City ____________

which adapts it for vitamin assay and other work with fluorescent materials. Also on display will be the new Model 12 electronic fluorophotometer.

Eastman Kodak Co. Rochester, N. Y.

Some few months ago, this company announced a new product—Eastman industrial X-ray films. These were specifically designed to meet the requirements of those engaged in the detection of internal flaws in manufactured articles either by X-rays or gamma radiation. Radiographs of this work will be displayed.

Federal Classifier Systems, Inc. Chicago

Laboratory air classifying instruments for separating ground material according to particle size will be displayed. The latest design incorporates graduated valves for controlling air volume air pressure, and mesh, this device serving actual production as well as research. These classifiers are widely used by the plastic industry, in powder metallurgy and in numerous other important industries. Operates from any lighting locket.

Gaertner Scientific Corp. Chicago

Among the instruments and precision apparatus which will be displayed by this company are spectrographs and kindred equipment, toolmakers microscopes, precision optical bench, interferometers, and other items of definite interest in testing and research in materials.

The Emil Greiner Co. New York

This display will feature the Diller photoelectric colorimeter for determining the color of petroleum products. This gives color in a continuous scale of all the various fractions of petroleum, simplifies and speeds up the test, and can be handled by operators without any special technical training. It is planned to exhibit the Mac Coull tester for the corrosion effect of internal combustion lubricants in contact with standard alloy bearings, particularly for airplane engines. This instrument provides a practical means for evaluating and grading these oils in the laboratory.

Humboldt Mfg. Co. Chicago

This company, manufacturers of a wide range of testing instruments and equipment used in investigating materials, will display testing sieves, asphalt testing equipment, apparatus for analysis of concrete, testing molds, and such items.

Illinois Testing Laboratories, Inc. Chicago

Typical items of this company's line will be demonstrated: Indicating and controlling pyrometers, including portable types, resistance thermometers in both portable and mounted types, and the instantaneous direct reading air velocity meter known as the Velometer. Of particular interest will be the improved "Alnor" Pyrocon for surface temperature measurements. New features provide for complete interchange by thermocouple without any change in the instrument calibration, also the quick detachability feature of the connector arm and the interchangeability between the rigid and flexible arm. This instrument is used for readings of revolving rolls, molds, platens, and other surfaces, also plastic material temperatures and general research work.

Instrument Specialties Co., Inc. Little Falls, N. J.

The first public showing of the electronic micrometer "pressureless" measuring instrument with a sensitivity to differences as small as five millionths of an inch will be a feature of the display of this company. The measuring devices to be displayed will include instruments designed specifically for precision measurements of soft or compressible materials such as rubber, paper, felt, fabrics, and plastics. Also featured will be an instrument for measuring diameter, out-of-round and enamel thickness of insulated wire.

Kimble Glass Co. Vineland, N. J.

The Kimble Glass Co.'s 1941 exhibit will include laboratory glassware used in many methods of test; also on display will be a representative selection of apparatus from the complete Kimble line.

Lancaster Iron Works, Inc. Lancaster, Pa.

Lancaster mixers will be the principal theme of the display, with several operating stock models, including the recently developed laboratory Model TM. Two other stock models recommended for control and small batch production work, each larger in size, respectively, will also be on display. There will also be shown a scale model of the 9 cu. ft. Lancaster mixer, Symbol EAG-4.

Leeds & Northrup Co. Philadelphia

Two new pieces of testing equipment will be displayed. Of particular interest is the new thermocouple checking furnace and equalizing block which enables you to check thermocouples within ± 1 F. from room temperature to 1000 F. Also on display for the first time will be L&N's convenient new glass electrode pH indicator. Other equipment shown will include a type K2 potentiometer, a potentiometer-type optical pyrometer, a Schering Bridge, and the accurate universal pH indicator.

"Metals and Alloys" New York

Exhibiting *Metals and Alloys,* "The Magazine of Metallurgical Engineering," which has had a steady increase in paid circulation during the past twelve months. The total monthly net paid circulation now stands at over 10,000 copies. The publishers will also exhibit a number of technical and engineering books of interest to testing engineers.

National Carbon Co., Inc. Cleveland

The exhibit will include an interesting demonstration of its Accelerated Weathering and Fading Units. The machines will be in operation and samples of results will be shown. This will be one of the first demonstrations of the new Model XV Accelerated Fading Unit, a testing machine with many novel features.

Parr Instrument Co. Moline, Ill.

Featured in this display will be a complete assortment of Parr reaction bombs and accessories for various test purposes. Three different styles of oxygen combustion bombs and six different sodium peroxide combustion bombs will be shown. Extreme pressure reaction equipment will be displayed, including a hydrogenation bomb capable of handling gas pressures up to 6000 psi. at 400 C. An adiabatic calorimeter together with other new and improved items of Parr apparatus will also be demonstrated.

Precision Scientific Co. Chicago

This company will show in addition to a timely selection of apparatus for testing cement, lime, gypsum and petroleum products—several new developments never before exhibited. These will include the Motor-Matic grease worker, the S.I.L. Mobilometer, a new rapid setting differential thermometer, an automatically controlled low-temperature storage cabinet, and an approved assembly of their patented Front-View petroleum distillation apparatus recently approved by the Society.

Radium Chemical Co., Inc. New York

Radium Chemical Co., Inc., will display radiographs taken by radium. The equipment used in radium-radiography will be demonstrated by the representatives in attendance.

Riehle Testing Machine Division, American Machine and Metals, Inc. East Moline, Ill.

Intends to exhibit improved extensometers, elongation percentage gages, and a number of small testing machines, among which a new Brinell tester and a motor operated cement tester will be especially interesting because their design departs rather radically from conventional models.

E. H. Sargent and Co. Chicago

Featuring the display of this company will be the Heyrovsky polarograph, an instrument of widespread application in the field of materials. Other selected items will be made from the wide range of materials it handles, including glassware, metalware, precision instruments, and equipment used in fields of chemistry, physical testing and the like.

Schaar and Co. Chicago

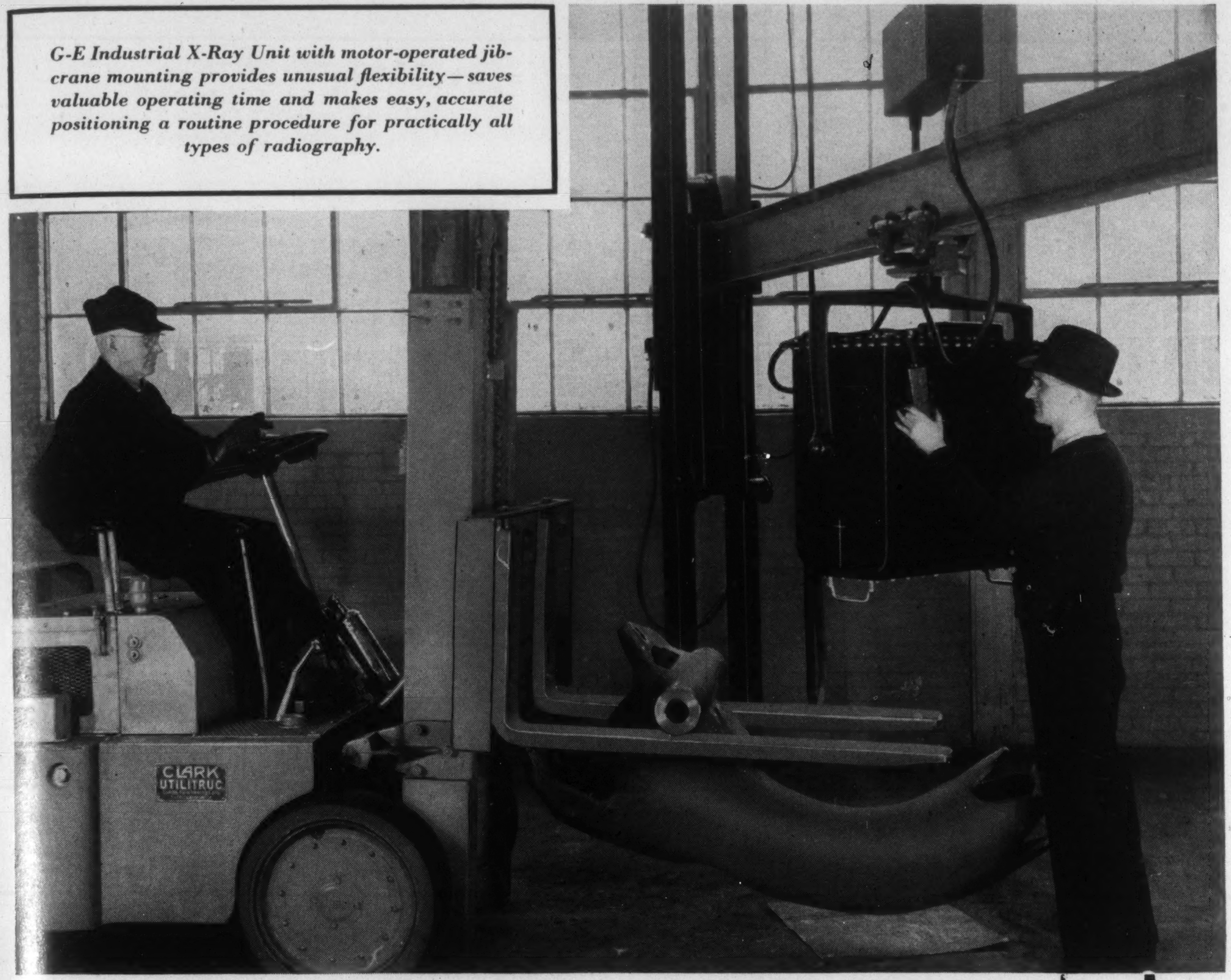
This company's exhibit will feature the Lumetron photoelectric colorimeter and fluorescence meter. This is a machine of great value in the analysis of vitamins, in the measurement of fluorescence, and in general colorimetric analysis. The accuracy and reproducibility of the measurements make the instrument a most valuable laboratory tool. Also included in the exhibit will be complete equipment for the laboratory.

C. J. Tagliabue Manufacturing Co. New York

This company, makers of indicating, recording, and controlling instruments, will have an interesting display of many new and improved instruments for testing materials, including the following recent developments: Tag celectray throttling indicating controller for creep test furnaces; the new vibration-proof celectray indicating controller which is sensitive to temperature change but not sensitive to vibration; and the Celectray multiple point temperature recorder. The new Tag-Heppenstall moisture meter, "dielectric" type which supplements its present line of Tag-Happenstall moisture meters for grain, lumber, tobacco, etc., and extends the field of moisture measurement by electrical instruments to solutions and powders.

Wilson Mechanical Instrument Co., Inc. New York

In addition to the Rockwell hardness tester and the Rockwell superficial hardness tester in the latest models, there will be in operation the Tukon tester for determination of the Knoop hardness number. This tester offers a new method of testing which requires minute, high precision penetrators and optical measurement of indentation, because only by such method is there at present any hope for high precision hardness tests on very thin or brittle or shallow surface conditions that require still smaller indentations and still lighter loads than are possible even with the Superficial model of our Rockwell tester. The Tukon tester, under selected weights, applies loads that may be varied from 0.1 kg. to 3.5 kg. The tester is fully automatic under electronic control in a synchronous cycle.



G-E Industrial X-Ray Unit with motor-operated jib-crane mounting provides unusual flexibility—saves valuable operating time and makes easy, accurate positioning a routine procedure for practically all types of radiography.

HOW MUCH IS INSPECTION TIME WORTH IN YOUR PLANT?

☆

TODAY, inspection time has a dollar-and-cents value that can be figured in terms of more goods produced per working hour. Its intrinsic value is just as tangible when figured in terms of the vital need by the nation for the products of your plant.

Here, then, are sound reasons why it will be profitable for you to investigate G-E Industrial X-Ray Units: You can't risk inspection facilities that may bog down production schedules; you can't take chances with quality; you must not waste one cent's worth of inspection or production time! And you can rest assured that you won't when G-E x-ray units are on the job!

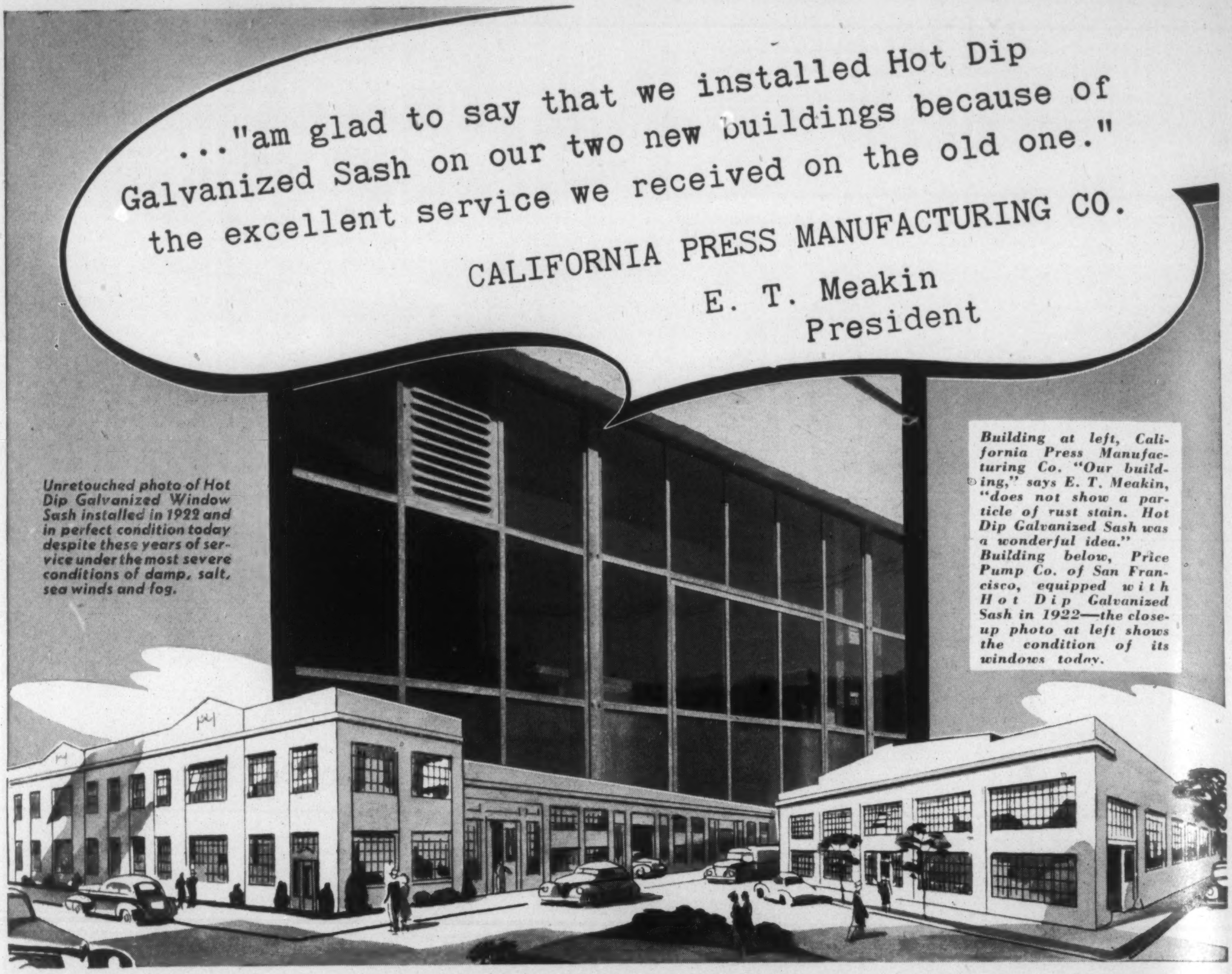
The majority of important concerns employing x-ray have selected G-E Industrial X-Ray Units because they are: PLUS POWERED, FLEXIBLE, 100% SAFE, EASY TO OPERATE, and ENGINEERED TO THE JOB. They're built to withstand the rigorous service expected of heavy industrial equipment; they'll take heavy duty cycles in their stride with day-in-and-day-out dependability.

To get the full story about these and the many other important exclusive G-E features, take advantage of the services of experienced G-E X-Ray engineers in applying x-ray examination to your inspection problem. You can rely on G-E engineers and equipment—both are backed by years of experience in the application and design of industrial x-ray apparatus.

To request further information and/or a personal call from a G-E X-Ray engineer who will be glad to supply the facts and figures you need, act today, write or wire Department R26.

**GENERAL ELECTRIC
X-RAY CORPORATION**

2012 JACKSON BLVD. CHICAGO, ILL., U. S. A.


..."am glad to say that we installed Hot Dip Galvanized Sash on our two new buildings because of the excellent service we received on the old one."
CALIFORNIA PRESS MANUFACTURING CO.
E. T. Meakin
President

Unretouched photo of Hot Dip Galvanized Window Sash installed in 1922 and in perfect condition today despite these years of service under the most severe conditions of damp, salt, sea winds and fog.

Building at left, California Press Manufacturing Co. "Our building," says E. T. Meakin, "does not show a particle of rust stain. Hot Dip Galvanized Sash was a wonderful idea." Building below, Price Pump Co. of San Francisco, equipped with Hot Dip Galvanized Sash in 1922—the close-up photo at left shows the condition of its windows today.

19 YEAR OLD WINDOW SASH
CONTINUES TO DEFY RUST BECAUSE IT'S
HOT DIP GALVANIZED

From coast to coast, countless installations of Hot Dip Galvanized Steel Sash stand as irrefutable evidence of its long, low-cost life . . . There is no substitute for *genuine* Hot Dip Galvanizing . . . This rust preventive process automatically guarantees a *thicker* coating of zinc fused as an inseparable *part* of the steel beneath. It is the most practical and economical rust protection known to modern metallurgy . . . Patronize members of this association and *know* that you are getting a genuine *quality* hot dip job on *every* order. Write for literature. American Hot Dip Galvanizers Association Incorporated, American Bank Building, Pittsburgh, Penna.

IF IT CARRIES THIS SEAL IT'S A JOB WELL DONE

OFFICIAL • INSIGNIA
GALVANIZED PRODUCTS
PROTECTED BY GENUINE
HOT·DIP
GALVANIZING
AMERICAN HOT DIP GALVANIZERS ASSOCIATION INC.

Acme Galvanizing, Inc., Milwaukee, Wis. ★ Acme Steel & Malleable Iron Works, Buffalo, N. Y. ★ American Tinning & Galvanizing Co., Erie, Pa. ★ Atlantic Stamping Co., Rochester, N. Y. ★ Atlantic Steel Co., Atlanta, Ga. ★ Buffalo Galvanizing & Tinning Works, Inc., Buffalo, N.Y. ★ Diamond Expansion Bolt Co., Inc., Garwood, N.J. ★ Equipment Steel Products Division of Union Asbestos and Rubber Co., Blue Island, Ill. ★ The Fanner Mfg. Co., Cleveland, O. ★ John Finn Metal Works, San Francisco, Cal. ★ Thomas Gregory Galvanizing Works, Maspeth, N.Y. ★ Hanlon-Gregory Galvanizing Co., Pittsburgh, Pa. ★ James Hill Mfg. Co., Providence, R.I. ★ Hubbard & Co., Oakland, Cal. ★ Independent Galvanizing Co., Newark, N.J. ★ International-Stacey Corp., Columbus, O. ★ Isaacson Iron Works, Seattle, Wash. ★ Joslyn Co. of California, Los Angeles, Cal. ★ Joslyn Mfg. & Supply Co., Chicago, Ill. ★ L. O. Koven & Brother, Inc., Jersey City, N.J. ★ Lehigh Structural Steel Co., Allentown, Pa. ★ Lewis Bolt & Nut Co., Minneapolis, Minn. ★ Missouri Rolling Mill Corp., St. Louis, Mo. ★ The National Telephone Supply Co., Cleveland, O. ★ Penn Galvanizing Co., Philadelphia, Pa. ★ Riverside Foundry & Galvanizing Co., Kalamazoo, Mich. ★ San Francisco Galvanizing Works, San Francisco, Cal. ★ The Sanitary Tinning Co., Cleveland, O. ★ Standard Galvanizing Co., Chicago, Ill. ★ Wilcox, Crittenden & Company, Inc., Middletown, Conn. ★ The Witt Cornice Company, Cincinnati, O.

FROM OUR FILES—CASES NOS. 0432-3-4, Steel Sash, Hot Dip Galvanized by SAN FRANCISCO GALVANIZING WORKS. Additional evidence furnished on request.

DEMANDED!

.. PRODUCTION STEP-UP IN MACHINE TOOL INDUSTRY

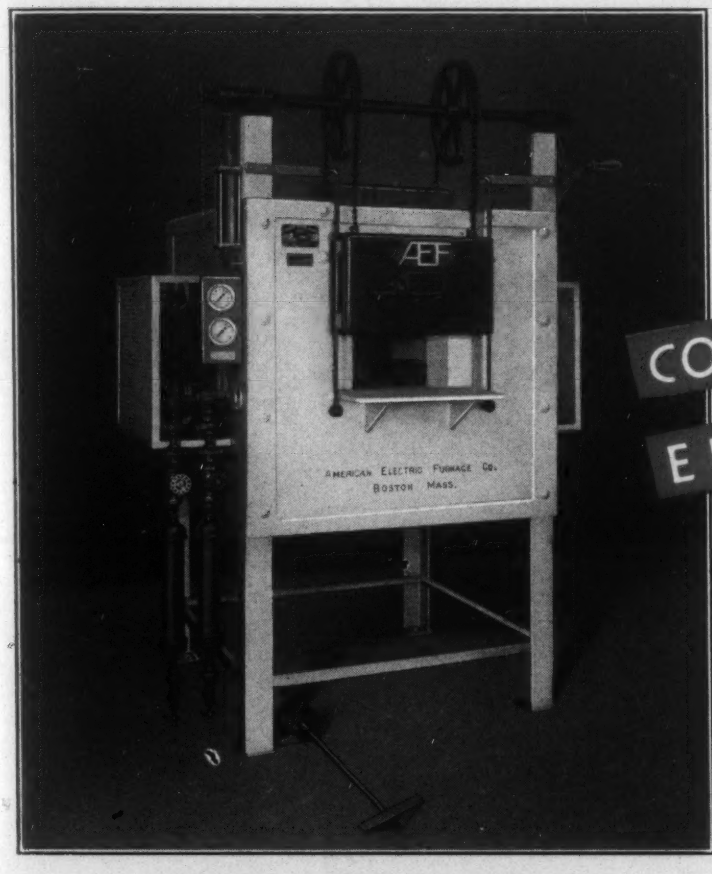
Here's how

"AMERICAN"

CONTROLLED ATMOSPHERE
ELECTRIC FURNACES

can help you

MEET YOUR SCHEDULES



HB1218 HIGH SPEED FURNACE
with Atmospheric Control and Air Operated Door.
Chamber 12"w. x 18"l. x 8"h.

"AMERICAN" Electric Preheating Furnaces have the same type atmospheric control. Use a matched pair of preheat and high speed and achieve maximum results.

"AMERICANS" will give you dependable day and night service on production operation. They are built to "take it." With them you obtain temperature uniformity and quality control at the same time reducing your rejections. You can work to closer limits of accuracy with protection from decarburization, scaling, and burning. Your operating expense will be less and your maintenance costs reduced.

Now is the time to "BUY AMERICAN."
Write today for price and delivery.

AEF

American Electric Furnace Company

29 VON HILLERN ST. ★ BOSTON, MASS., U. S. A.
Industrial Furnaces for All Purposes

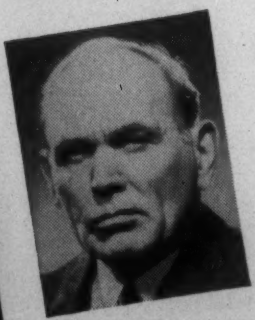
These men are ta

"Now that we're working on defense orders our past experience with U·S·S Carilloy Alloy Steels is invaluable. Although we are daily running into new and unfamiliar problems of production we know that we can confidently rely on Carnegie-Illinois to give us the right Alloy Steel and help us to use it to best advantage. By using U·S·S Carilloy Alloy Steel we are assured of uniformity of response to our heat treatment. That's mighty important today when we must maintain a high rate of production with no sacrifice in quality."

"Suggested steel change-over saves us $70 a day on raw material cost alone. Formerly we used a highly alloyed steel for an intricate gear in the drive mechanism we manufacture. After a comprehensive survey of all properties required, your metallurgist suggested the use of an alternate type of alloy steel which meets all requirements, and saves us $19 per ton in raw material cost alone. It actually effects further economy because the new steel is considerably more machinable."

"When we built the 'Jumbo' earth-moving trucks we insured their dependability by making all vital parts of U·S·S Carilloy Alloy Steel. In this multi-wheeled road giant, front and rear axles, transmission and steering parts throughout are made of U·S·S Carilloy Alloy Steel. They help to keep these trucks on the job day after day and to assure profitable operation."

"We are drilling oil wells deeper and 5 times faster than 10 years ago, because of improvements in drilling equipment made possible by better alloy steels. U·S·S Carilloy Alloy Steels in drill bits, drill collars, Kelly bars and auxiliary drilling equipment have given us, at reasonable cost, high speed drilling equipment better able to stand the rough usage that oil field equipment must take. The toughness, strength and wearing qualities of these alloy steels make it possible to drill at speeds and at depths undreamed of only a few years ago."



"Our forge shop is a busy place today. The present emergency has created a production volume with exceptionally high quality standards which must be met. U·S·S Carilloy Alloy Steels help us meet these requirements most economically in our forgings for ordnance equipment, aircraft and marine engines."

U·S·S CARILLOY *Dependable*

talking your language

...And what they say about Carilloy Alloy Steels is important

WHETHER your work today is on production for defense or for domestic consumption your problems as they involve steel are basically the same.

To insure uniform and maximum service of any product made by mass production methods, and to do it economically, you must use the least expensive steel that can provide the maximum performance in the finished part. We are prepared to assist you in selecting such a steel for your purpose.

In U·S·S Carilloy Alloy Steels we offer you a complete range of superior quality S.A.E. Alloy Steels, Aircraft Quality Steels, and Special Alloy Steels for all purposes. U·S·S Carilloy Alloy Steels are produced in modern mills in which the most advanced facilities are matched by the skill of experienced operating and metallurgical personnel.

To help you in properly selecting the steels best fitted for your needs and to assure the most economical treating procedure with the equipment available in your plant, we offer you the assistance of our metallurgical staff. These men know steel. They are familiar with the most advanced shop methods of using it. If your job can be done better, or faster, or at lower cost, they are competent to point out a way to do it.

CARNEGIE ILLINOIS STEEL CORPORATION
Pittsburgh and Chicago
Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Export Company, New York

UNITED STATES STEEL

ALLOY STEELS

LOW TEMPERATURE BRAZING *with* SIL-FOS . . .

. . . solved this warping problem

The job of brazing the three brass bosses, with their comparatively thick flanges, to the 1/16″ brass beverage cooler shell used to be a troublesome one. The shell warped badly, due mainly to the high temperature at which the brazing was done.

A change to SIL-FOS, plus HANDY FLUX, and the use of the simple set-up shown, ended the warping entirely. Here are the reasons why—

SIL-FOS is exceptionally free-flowing and fast-acting at the low temperature of 1300 Deg. F. Hence the shell is now subjected to far less heat and for a much shorter time. Suspending the shell from above and concentrating the heat on the flange of the boss, as shown, helped bring about the good results. The low flow point of SIL-FOS also gives this important advantage—it avoids the danger of damaging the metal in the thin gauge shell.

HANDY FLUX is important too, because it is entirely fluid and active at 1100 Deg. F. and makes it possible to take full advantage of the low flow point of SIL-FOS.

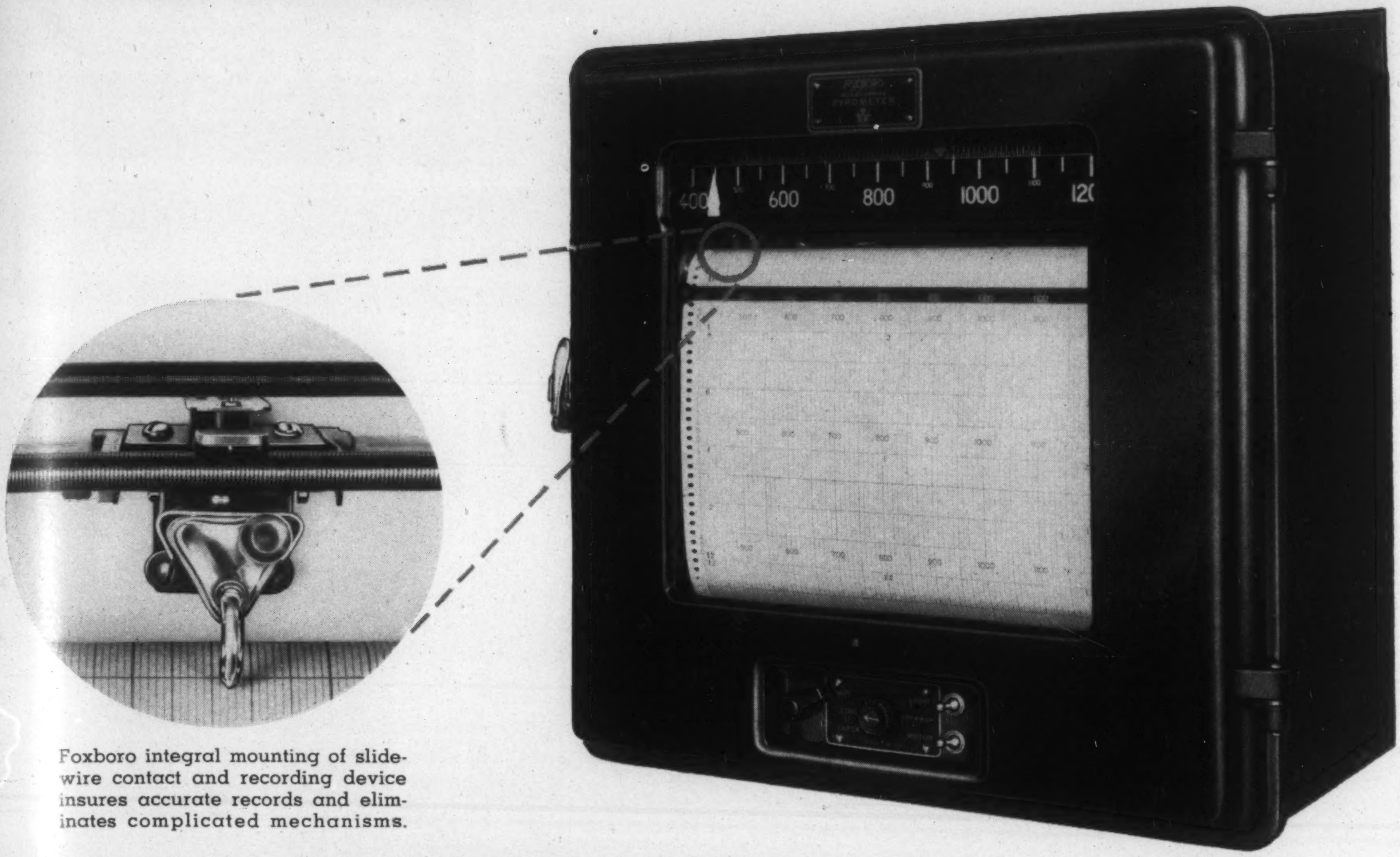
SIL-FOS MAY BE YOUR ANSWER TOO

If you have a non-ferrous metal joining problem — whether it's one of warping, improving joint quality or speeding up production — it is more than likely that SIL-FOS plus HANDY FLUX plus the right brazing technique will solve it. We'll be glad to send a field engineer to help you find out. For SIL-FOS details write for Bulletin MA-56.

HANDY & HARMAN 82 FULTON ST., NEW YORK

Agents in Principal Cities. In Canada: HANDY & HARMAN of Canada, Ltd., Toronto

RELIEF FOR SHORT-HANDED PLANTS!



Foxboro integral mounting of slide-wire contact and recording device insures accurate records and eliminates complicated mechanisms.

These wear-proofed pyrometers cut supervision and maintenance to the bone!

Never before has *dependability* in a pyrometer meant so much to industry as right now! Production must be boosted without sacrifice of quality . . . with new, trained operators unobtainable. Instruments must give uninterrupted service, months on end, with minimum attention from short-handed maintenance gangs!

That is why so many leading defense industries have specified definite preference for Foxboro Potentiometer Instruments on their reorders. In every detail of design and construction, these instruments are engineered to eliminate lost motion, wear and service interruptions.

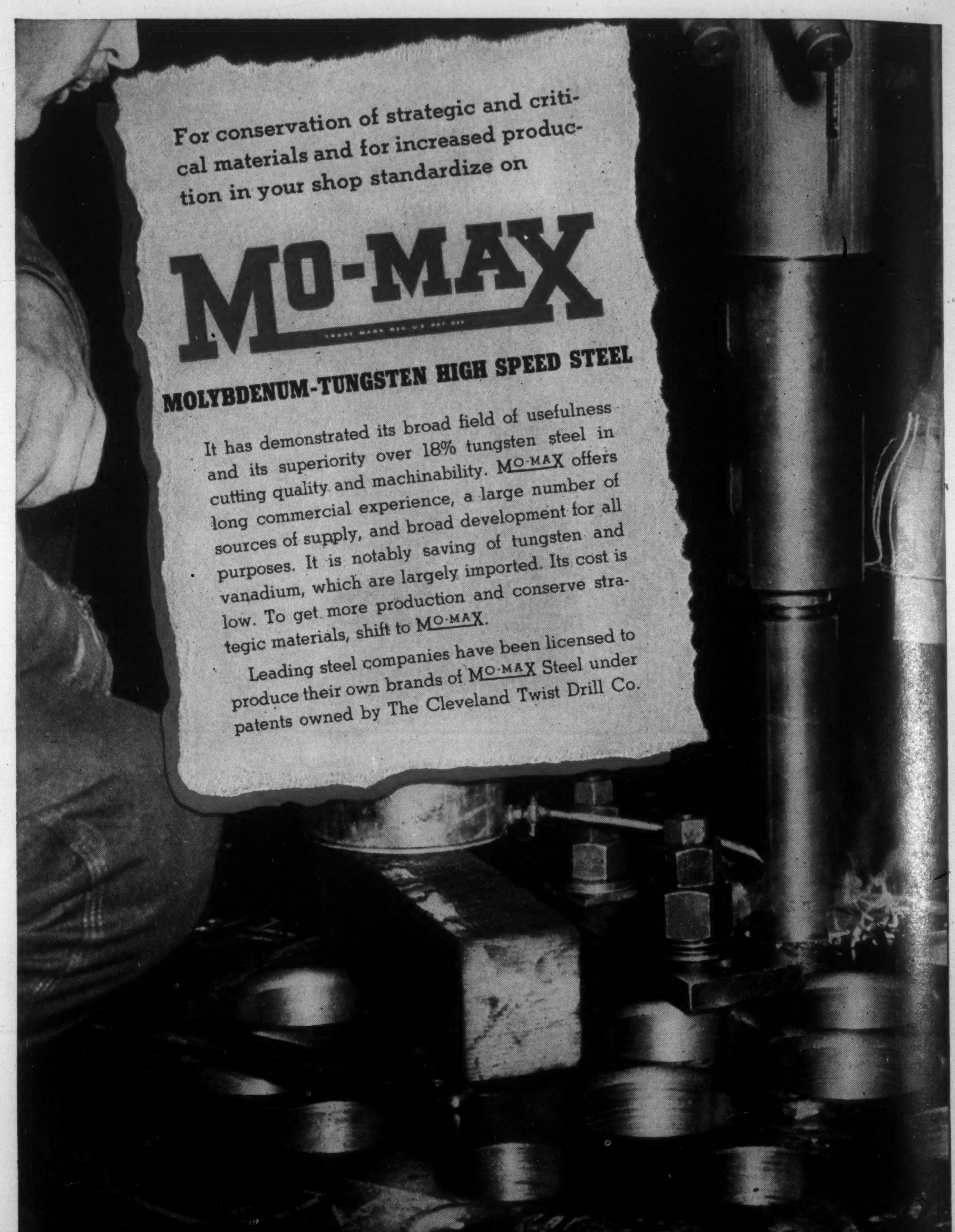
For example, Foxboro integral mounting of slide-wire contacts and recording device is typical. It eliminates a complete gear train . . . prevents transmission errors . . . saves maintenance usually demanded by gear-wear. Other original Foxboro refinements include ball bearings at every important point . . . galvanometer suspensions that *do not break* . . . and a fast-acting, practically wear-proof balancing device.

Get the complete story. Write for Bulletin 190-5. **The Foxboro Company, 54 Neponset Avenue, Foxboro, Mass., U. S. A.** Branches in principal cities of United States and Canada.

—RECORDING • CONTROLLING • INDICATING— **FOXBORO** —

Reg. U. S. Pat. Off.

Potentiometer Instruments



For conservation of strategic and critical materials and for increased production in your shop standardize on

MO-MAX

MOLYBDENUM-TUNGSTEN HIGH SPEED STEEL

It has demonstrated its broad field of usefulness and its superiority over 18% tungsten steel in cutting quality and machinability. MO-MAX offers long commercial experience, a large number of sources of supply, and broad development for all purposes. It is notably saving of tungsten and vanadium, which are largely imported. Its cost is low. To get more production and conserve strategic materials, shift to MO-MAX.

Leading steel companies have been licensed to produce their own brands of MO-MAX Steel under patents owned by The Cleveland Twist Drill Co.

MO-MAX tool bit boring holes in steel plate at a U. S. Navy Yard.

If You Can't Get Certain Alloys, Perhaps Others Will Do As Well

YES, some alloys are hard to get these days. But it is often possible to substitute one alloy for another or one grade for another and still obtain the same final result without materially changing steel-making practice. The desired properties in steel can often be obtained with different combinations of alloying elements.

If you make iron or steel, perhaps we can suggest what ferro-alloys you can substitute to overcome supply difficulties and how you can change your practice and still make a quality product. If you use steel, we can help you select substitute alloy steels suitable for the job. This service is backed by over 35 years' experience in the production and use of high-grade ferro-alloys, and includes a staff of competent metallurgists who are ready to give you practical, on-the-job help. Why not ask for this service whenever you need it, without obligation.

ELECTRO METALLURGICAL COMPANY
Unit of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York, N.Y.

Items of Interest about "Electromet" Ferro-Alloys

•

High-Nitrogen Ferrochrome Gives Grain Refinement—High-nitrogen ferrochrome added in the furnace to produce high-chromium steels greatly refines grain size. The nitrogen introduced with the chromium develops strength and toughness without sacrificing machinability.

Columbium Prevents Intergranular Corrosion in the Austenitic Stainless Steels—A small amount of columbium in the austenitic stainless steels stabilizes the carbides and prevents intergranular corrosion even after the steel is held at temperatures ranging from 750 to 1,650 deg. F. for long periods. The columbium content should be from six to ten times the carbon content, depending on the service involved.

Use Low-Carbon Ferrochrome for Making High-Speed Tool Steels—Low-carbon ferrochrome is widely used instead of high-carbon ferrochrome for making high-speed tool steels. This practice inhibits the formation and segregation of hard chromium carbides and results in a more uniform steel.

Zirconium Improves 12 to 14 Per Cent Chromium Steels—Zirconium in the form of 35 to 40 per cent zirconium alloy is being successfully used as a final addition to 12 to 14 per cent chromium steels. This treatment eliminates pinholes and porosity in ingots and castings.

Columbium Stabilizes Toughness of the 4 to 6 Per Cent Chromium Steels—About 0.50 per cent of columbium in the wrought 4 to 6 per cent chromium steels makes these steels retain their toughness at room and sub-zero temperatures, after being subjected to the wide variety of temperatures encountered during fabrication and service. Even at 40 deg. below zero, the columbium-bearing steels do not become brittle regardless of the previous heat-treatment.

• • •

If you want more information about these and the many other "Electromet" ferro-alloys and metals and the service that goes with their purchase, write for the booklet, "Electromet Products and Service."

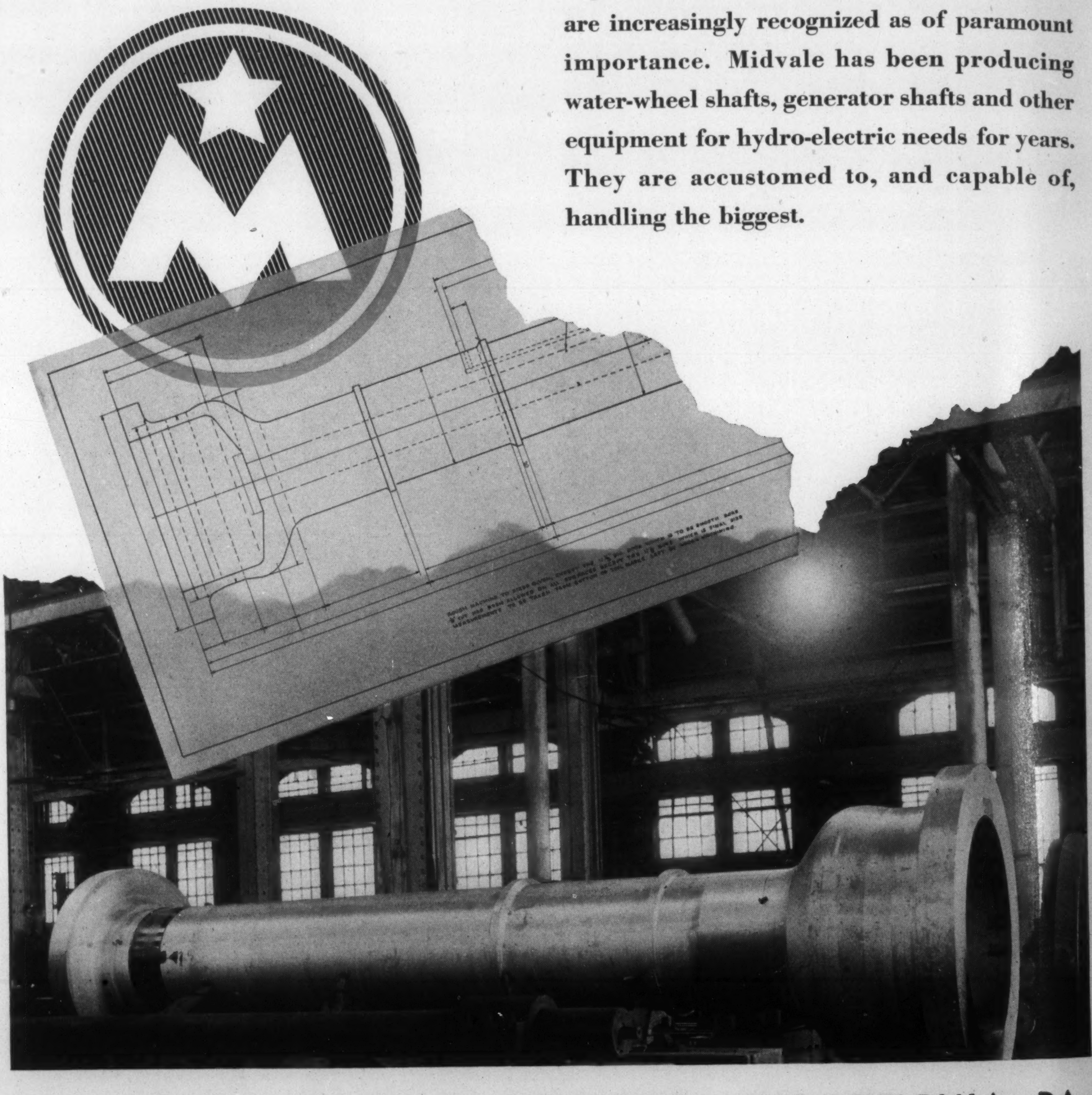
Electromet
Trade-Mark
Ferro-Alloys & Metals

Available through offices of Electro Metallurgical Sales Corporation in Birmingham, Chicago, Cleveland, Detroit, New York, Pittsburgh, and San Francisco. In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario.

PRODUCTS OF A UNIT OF
UCC
UNION CARBIDE AND CARBON CORPORATION

The word "Electromet" is a registered trade-mark of Electro Metallurgical Company.

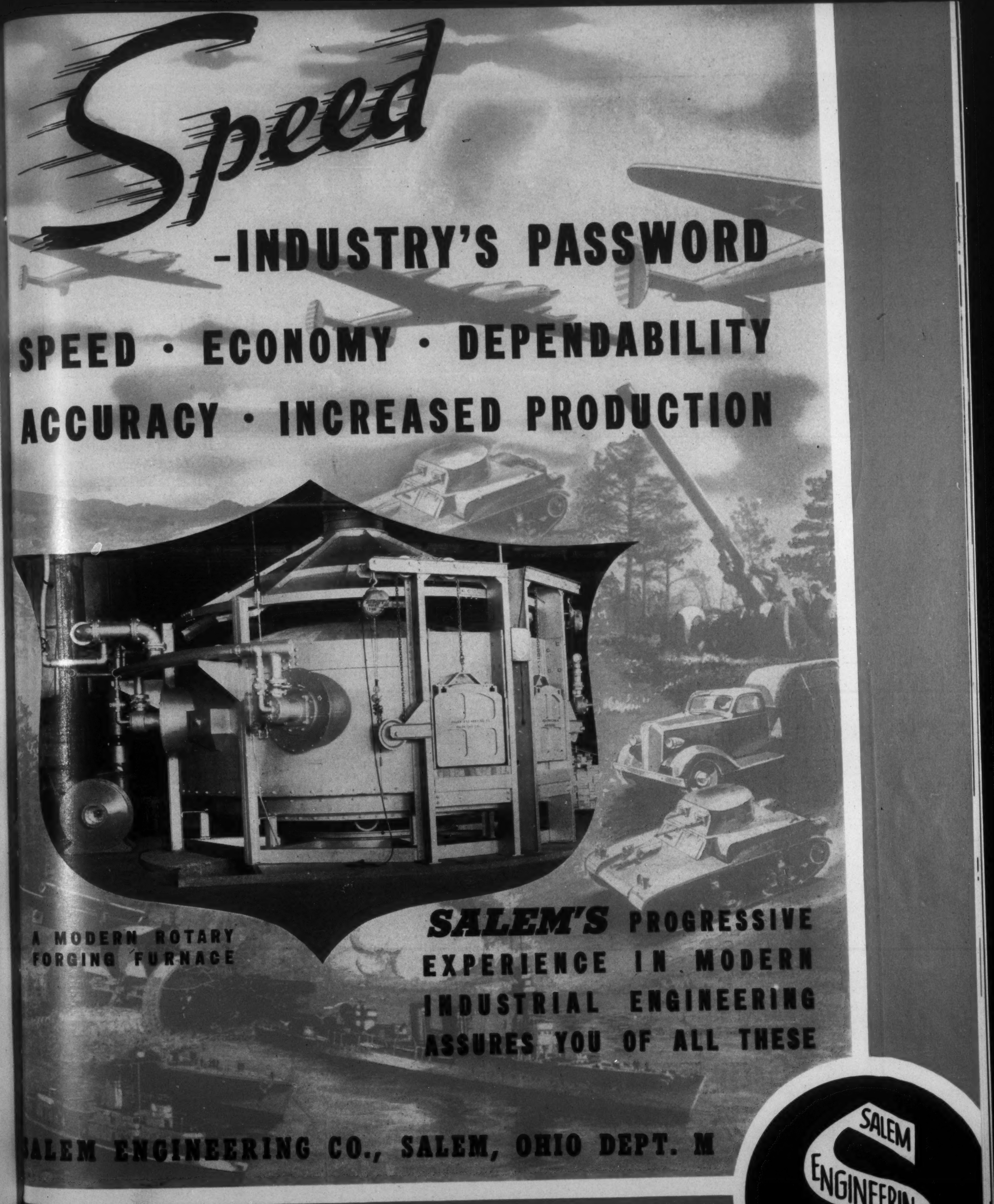
THE vital link between your water and your generator is the water-wheel shaft. With both defense, and business generally, putting a pressure on industry never experienced before—hydro-electric projects are increasingly recognized as of paramount importance. Midvale has been producing water-wheel shafts, generator shafts and other equipment for hydro-electric needs for years. They are accustomed to, and capable of, handling the biggest.



THE MIDVALE COMPANY • NICETOWN • PHILADELPHIA, PA.

OFFICES: ***New York • Chicago • Pittsburgh • Washington • Cleveland • San Francisco***

MIDVALE



Speed

-INDUSTRY'S PASSWORD

SPEED · ECONOMY · DEPENDABILITY

ACCURACY · INCREASED PRODUCTION

A MODERN ROTARY
FORGING FURNACE

SALEM'S PROGRESSIVE
EXPERIENCE IN MODERN
INDUSTRIAL ENGINEERING
ASSURES YOU OF ALL THESE

ALEM ENGINEERING CO., SALEM, OHIO DEPT. M

SALEM
ENGINEERING
COMPANY

Sturtevant

How this Parts Manufacturer

SAVES MONEY

WITH DESIGN 9

STURTEVANT COMPRESSOR

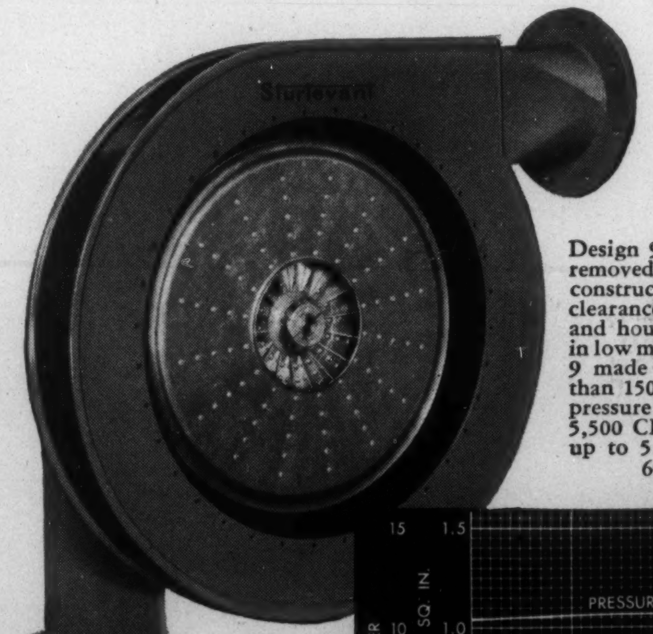
TYPICAL of the way Sturtevant Design 9 Compressors cut costs and increase efficiency is the case of Zierich Mfg. Co., Bronx, N. Y., manufacturers of small metal parts. Here a Sturtevant Design 9 Centrifugal Compressor replaced a 7½ h.p. rotary blower which required frequent repairs and adjustment.

With the Sturtevant unit, power consumption was immediately cut ONE-THIRD. Maintenance was reduced to a mere trifle. The simple, sturdy design of Sturtevant Compressors assures practically wearless service and the only care required is several yearly lubrications of the motor bearings. Moreover, operation is quiet and vibrationless.

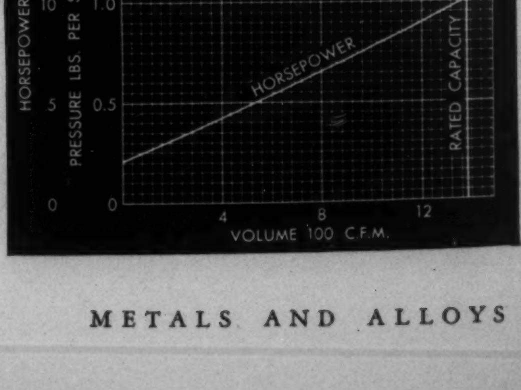
Especially important in maintaining constant heating temperatures under variable loads is the fact that Sturtevant Compressors hold a *constant pressure* over practically the complete volume range.

Why not let a Sturtevant Engineer study your requirements—and show you how the right type and size of Sturtevant Compressor, properly installed, can step up efficiency and step down maintenance in supplying air to furnaces, ovens and other equipment.

Complete performance data and specifications on Sturtevant Centrifugal Compressors furnished by your nearest Sturtevant office—or write direct to Hyde Park.



Design 9—with front plate removed to show rugged construction. Note wide clearance between rotor and housing which results in low maintenance. Design 9 made in 4 types, more than 150 sizes, ½ to 3 lbs. pressure — volumes up to 5,500 CFM. Other designs up to 5 lbs. pressure and 60,000 CFM.



Performance chart illustrating ability to deliver wide range of air volume at constant pressure.

A FEW OF INDUSTRY'S LEADERS USING STURTEVANT COMPRESSORS

Caterpillar Tractor Co.
Republic Steel Co.
American Steel & Wire Co.
Bethlehem Steel Co.
Inland Steel Co.
National Twist Drill & Tool Co.
Great Lakes Steel Corp.
Standard Nut & Bolt Co.
Jones & Laughlin Steel Corp.
Habirshaw Cable & Wire Corp.
Foster-Wheeler Corp.
Youngstown Sheet & Tube Co.
Aluminum Co. of America
Link Belt Co.
North & Judd Mfg. Co.
Newport Rolling Mill Co.
Rochester Smelting & Refining Co.
Albion Malleable Iron Co.
Federated Metals Division of
American Smelting & Refining Co.

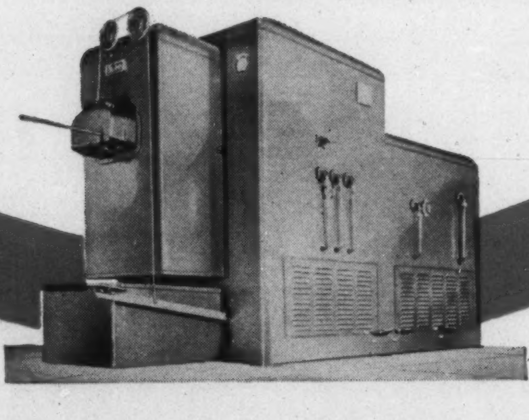
Sturtevant
REG. U. S. PAT. OFF.
Puts Air to Work

B. F. STURTEVANT CO., Hyde Park, Boston, Mass.
Branches in 40 Other Cities
B. F. Sturtevant Co. of Canada, Limited—Galt, Toronto, Montreal

LITHCO LITHCO LITHCO LITHCO LITHCO LITHCO LITHCO LITHCO LITHCO LITHCO LITHCO LITHCO LITHCO

Bright decarb-free hardening

...at *all* times!



No idle claims, no qualified claims—absolutely clean hardening without decarburization, carburization or scaling is possible with the LITHCO Atmosphere Furnace . . . anytime, anywhere and by any operator. Because LITHCO is a chemically-neutralized process, all steels can be heated simultaneously. The LITHCO Atmosphere Furnace is completely automatic; no adjustments are necessary or provided. Operation is simple, easy and foolproof.

If you have a heat-treating problem, investigation of the LITHCO process will cost you nothing. Write today for illustrated literature describing the complete line of LITHCO batch, pit and continuous types of heat-treating and LITHCARB gas-carburizing units.

LITHCO... A MIRACLE OF CHEMISTRY

THE LITHIUM CORPORATION
GENERAL OFFICES
RAYMOND-COMMERCE BLDG., NEWARK, NEW JERSEY

FROM BILLETS
TO BULLETS *Faster...*

with AIRCO MACHINE GAS CUTTING

Speeding-up an important step in the manufacture of shells is one of the defense jobs assigned to this Airco Radiagraph Gas Cutting Machine. 65 blanks an hour are being cut from 3½-inch thick billets of .45-.50 carbon steel. *Due to the slightly rounded edges of the billets, this illustration shows a hand torch being used as a preheating medium;* otherwise the notched effect between the parallel billets would lower the efficiency of the billet-cutting operation. » » » This is but one of the many ways in which Airco gas cutting machines are helping to accelerate the defense program. Where quantities of machine gas cut parts are required — whether large or small — there's an Airco machine to do the job, quickly, accurately, economically. Visible evidence of this can be seen in hundreds of plants where Airco machines are daily speeding production on thousands of different products. A new booklet describing the No. 4 Radiagraph shown above may help end your metal-cutting headaches. A request on your company letterhead will bring a copy promptly.

Air Reduction

General Offices: 60 EAST 42nd ST., NEW YORK, N. Y.
DISTRICT OFFICES IN PRINCIPAL CITIES

AIRCO WILSON

Anything and Everything for GAS WELDING or CUTTING and ARC WELDING

RUSTLESS

PREPARED FOR TODAY ... *and* TOMORROW

The increased capacity (doubled and redoubled within the past six years) that helps us meet today's demands for stainless steel is not just a reply to an emergency. It was an answer to a constantly expanding peace-time demand, from customers who recognized the value that stainless steel added to their products . . . and the value of the quality and uniformity that Rustless specialization adds to Rustless stainless steel.

When things get back to normal, competition will be keen. Many alert manufacturers are looking ahead by reviewing means of improving the appearance, serviceability, economy and sales-appeal of their products. In many cases, stainless steel is the easiest, most effective means of adding these qualities. Why not give some thought—now—to the use of Rustless stainless steel in the products you'll be making tomorrow?

RUSTLESS IRON AND STEEL CORPORATION
BALTIMORE, MARYLAND

RUSTLESS
STAINLESS STEEL
BARS AND WIRE

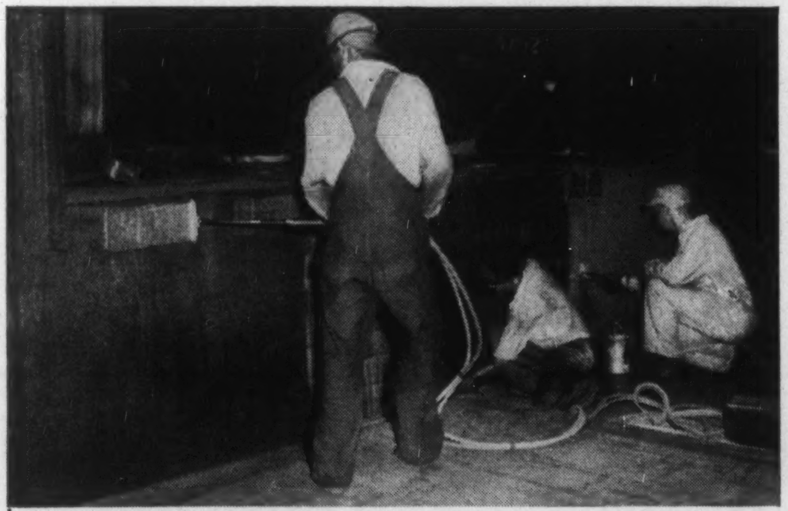
PRODUCED BY AN ORGANIZATION
MAKING NOTHING BUT STAINLESS STEEL

SALES OFFICES: BALTIMORE · BUFFALO · CHICAGO · CINCINNATI · CLEVELAND · DETROIT · LOS ANGELES · PHILADELPHIA
DISTRIBUTORS' WAREHOUSE STOCKS IN 18 CITIES

OXY-ACETYLENE FLAME-PRIMING makes paint go on faster and last longer . . .

1. What it is and does

Oxy-acetylene flame-priming is performed by passing the flame from an Oxweld heating head over structural steel before the first protective coating is applied. The quick heat causes rust and loose scale to pop off, and drives out the surface moisture, thus leaving a clean, dry surface for the paint. Structures of any size or shape can be flame-primed in the shop or on the job.



LINDE OXYGEN
PREST-O-LITE ACETYLENE
PREST-O-LITE ACETYLENE
PREST-O-LITE ACETYLENE

2. How it helps

Flame-priming is followed by wire-brushing, and close behind this comes the painting. As a result the metal is clean, dry, and still warm—making the paint go on faster, bond tighter, dry quicker, and last longer.

3. What you need to use it

All you need to use this method is an Oxweld W-26 heavy-duty welding blowpipe and an Oxweld flame-priming head, connected to an adequate source of oxygen and acetylene supply. Any operator can learn the technique quickly.

With standard welding heads, you can use your flame-priming equipment for heavy welding, and for straightening, forming, and other heating operations.

and Linde can help you use it!

Linde can supply the gases, the apparatus, and help in using flame-priming. If you are interested in giving longer life to paint jobs—or if you are confronted with bottlenecks in using sand-blasting equipment—*talk it over with Linde!*

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
General Office: New York, N. Y. UCC Offices in Principal Cities
In Canada: Dominion Oxygen Company, Limited, Toronto

LINDE OXYGEN . . . PREST-O-LITE ACETYLENE . . . UNION CARBIDE
OXWELD, PUROX, PREST-O-WELD APPARATUS . . . OXWELD SUPPLIES

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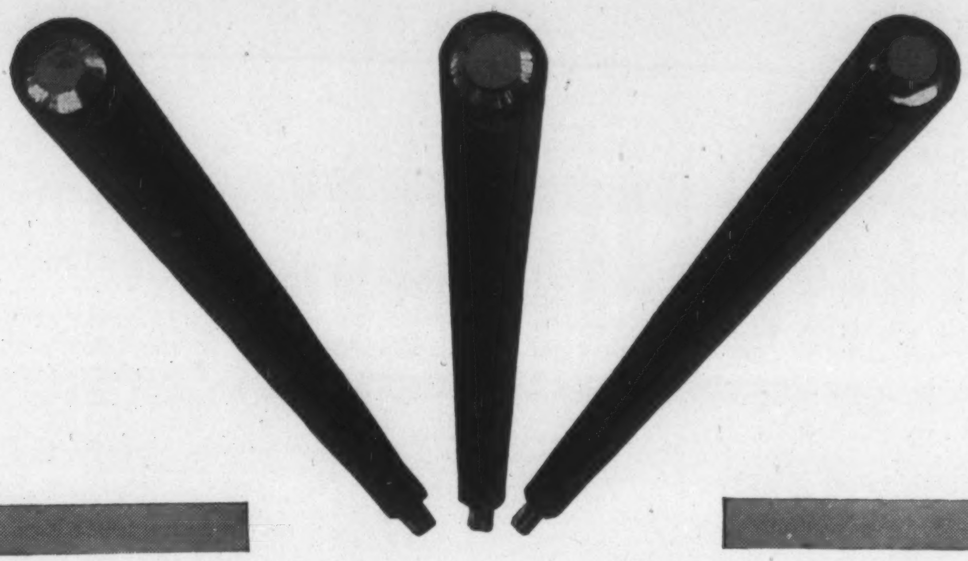

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BORGER, TEXAS	*Hart Industrial Supply Co.*
BOSTON, MASS. (Belmont)	*H. Boker & Co., Inc.; W. E. Fluke*
CHICAGO, ILL.	*Machinery & Welder Corp.*
CINCINNATI, OHIO	*Williams & Co., Inc.*
CLEVELAND, OHIO	*Williams & Co., Inc.*
COLUMBUS, OHIO	*Williams & Co., Inc.*
DETROIT, MICHIGAN	*C. E. Phillips & Co., Inc.*
ERIE, PENNA.	*Boyd Welding Co.*
FT. WAYNE, IND.	*Wayne Welding Supply Co., Inc.*
HONOLULU, HAWAII	*Hawaiian Gas Products, Ltd.*
HOUSTON, TEXAS	*Champion Rivet Co. of Texas*
INDIANAPOLIS, IND.	*Allied Weld-Craft, Inc.*
KANSAS CITY, MO.	*Welders Supply & Repair Co.*
KINGSPORT, TENN.	*Slip-Not Belting Corp.*
LOS ANGELES, CALIF.	*Ducommun Metals & Supply Co.*
MILWAUKEE, WIS.	*Machinery & Welder Corp.*
MOLINE, ILL.	*Machinery & Welder Corp.*
NEW YORK, N. Y.	*H. Boker & Co., Inc.*
OKLAHOMA CITY, OKLA.	*Hart Industrial Supply Co.*
PAMPA, TEXAS	*Hart Industrial Supply Co.*
PITTSBURGH, PA.	*Williams & Co., Inc.*
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SAN FRANCISCO, CALIF.	*Ducommun Metals & Supply Co.*
SEATTLE, WASH.	*H. A. Cheever Co.*
ST. LOUIS, MO.	*Machinery & Welder Corp.*
SYRACUSE, N. Y.	*Welding Supply Co.*
TOLEDO, OHIO	*Williams & Co., Inc.*

manufacturers' literature

Yours for the Asking

1. FERROUS METALS

Steel Buyer's Guide

Jos. T. Ryerson & Sons, Inc., have issued their largest and most complete steel buyer's guide—the company's 268-page 1941-1942 stock list. In addition to a complete list of Ryerson's steel-products stock, the book contains a wealth of helpful reference data. (1-130)

Mold and Die Steels

Jessop's Press E-Z hobbing steel—a low-carbon steel for making molds for plastics and dies for die castings by the hob-sinking method is completely described as to properties and processing in a 6-page folder of Jessop Steel Co. (1-129)

Copper-Clad Steel

An 8-page bulletin of Copperweld Steel Co. describes the manufacture and applications of copper-clad steel in the form of rod, wire, strands, nails, fencing, etc. (1-128)

Tool Steel Manual

Carpenter Steel Co. announces a 96-page tool steel manual, which alphabetically thumb-indexes all types of tools and dies, gives fabrication, heat treatment and service requirements, and includes a handy "selector" for quick location of the best steel for a given job. (1-127)

Molybdenum in Steel

Molybdenum Corp. of America is publishing a highly useful collection of data on the properties and performance of certain molybdenum steels. (1-126)

Tool Steels

The handsome new 75-page catalog on Disston tool steels, issued by Henry Disston & Sons, Inc., presents in an extremely interesting and useful way the story of the manufacture, properties, treatment and uses of the long line of tool steels made by this company. (1-123)

Fine Small Tubing

Superior Tube Co.'s handsome 12-page booklet reviews the company's facilities and gives some very interesting information on various applications of fine small tubing. (1-112)

Stainless Steels

A beautiful, illustrated 24-page booklet of Rustless Iron and Steel Corp. describes this stainless steel manufacturer's expanded facilities and its production methods, and gives interesting information on stainless steel products and applications. (1-105)

Free-Machining Carburizing Steel

In a handsome and technically useful 19-page bulletin, W. J. Holliday & Co. tell the story of "Speed Case"—a free-machining open-hearth case-carburizing steel—and of "Speed Treat"—a medium-carbon open-hearth high-tensile free-machining steel—with respect to properties, treatment, fabrication and uses. (1-103)

High Strength Steel

Information concerning chemical composition, physical properties and corrosion resistance of its low-alloy high strength steel is offered by Inland Steel Co. (1-90)

Molybdenum Iron and Steel

The Moly-Matrix, a monthly periodical of Climax Molybdenum Co., contains in each issue an interesting and informative engineering article on the application of molybdenum irons and steels in some specific industrial service. (1-76)

Mo-Max High Speed Steels

The new 3d edition of J. V. Emmons' interesting discussion of the composition, tool performance, heat treatment, forging, welding and cutting of the molybdenum-tungsten high speed steels includes 12 photomicrographs, with descriptive texts, showing the structural similarities between Mo-Max and 18-4-1. Cleveland Twist Drill Co. (1-11)

Moly High-Speed Steels

Firth-Sterling Steel Co. offers a bulletin on Mo-Chip high-speed steel, a new steel for taps said to offer an unusual combination of required hardness and extraordinary toughness. (1-65)

Nitriding Steels

The Nitralloy Corp. has just issued a 29-page engineering booklet (prepared by Dr. Homerberg) that covers in complete detail the whole field of nitriding—suitable steels, condition of steel, the nitriding process, applications in industry, etc. (1-33)

New High-Strength Steel

Complete mechanical property data on a new low-alloy, high strength and ductile steel, are given for strip, plate and bars in a folder of Great Lakes Steel Co. (1-2)

2. NON-FERROUS METALS

New Lead Roofing Sheet

A 4-page bulletin of Revere Copper & Brass, Inc., reviews in rapid-fire fashion the nature and advantages of Roofloy, a high-strength sheet lead roofing material. (2-125)

Uses of Indium

Indium Corp. of America is issuing reprints of a brief, interesting article describing the broadening uses of indium for alloying and surface coating. (2-124)

Special Bronze in Presses

Engineering Data Sheet No. 89 of Ampco Metal, Inc., describes the application of Ampco Metal for the dies, plunger and stripper of a well-known make of salt-tablet press. (2-123)

Molybdenum and Tungsten Products

A 48-page catalog of American Electro Metal Corp. gives detailed information on Elmet tungsten and molybdenum products made by powder metallurgy—their manufacture, properties, uses, etc. (2-122)

Lithium and Its Alloys

A 68-page reprint of a very important technical paper reviewing the properties and applications of lithium and its alloys is available for $1.50 from Lithaloys Corp., 444 Madison Ave., New York. (2-116)

Phosphor Bronze

Technical data on the 4 standard Elephant-brand phosphor bronzes in the form of rod, sheet and strip, spring wire, welding wire, wire ropes and bushings are systematically presented in a 10-page booklet of Phosphor Bronze Smelting Co. (2-100)

*Metal Hydrides—
Powders or Ingots*

Described and discussed in a new catalog of Metal Hydrides, Inc., are metal hydrides produced in powdered form or as sintered ingots for a variety of powder metallurgy or alloying applications. (2-96)

Magnesium Alloys

American Magnesium Corp. offers a comprehensive collection, in looseleaf form, of engineering data, specifications, properties, procedure for working, welding, painting, etc. of a full line of magnesium alloys. (2-57)

Low-Temperature Melting Alloys

The properties and uses of Cerromatrix, Cerrobase and Cerrobend non-shrinking, low melting-temperature alloys applicable to die making, pattern reproduction, tube bending and other applications are described and illustrated in a 4-page bulletin of Cerro de Pasco Copper Corp. (2-84)

Rare Metals, Alloys and Ores

Foote-Prints, a semi-annual journal, contains original, authoritative articles on the production and uses of the less common mineral products, and includes an extensive review of published literature. Foote Mineral Co. (2-19)

3. METAL FORMS · METAL PARTS · ENGINEERING DESIGN

Metric-English Conversion Card

An 8½ in. x 11 in. technical data card (No. 112) available from Babcock & Wilcox Co. provides easily-read conversions of millimeters to inches and comparisons of units of weight and length. (3-119)

Friction Materials from Powders

An effectively illustrated 44-page book of S. K. Wellman Co. demonstrates the diversified uses of "Velvetouch" sintered bi-metallic friction materials in friction-type clutches and brakes for machinery of all types. (3-118)

Bearings and the Defense Program

An outstanding, beautifully illustrated 36-page brochure of Timken Roller Bearing Co. explains the importance of tapered roller bearings in defense equipment and in the machinery from which such equipment is made. (3-117)

Porous Bronze Bearings

A new catalog giving specifications for "Selflube" porous bronze bearings and much information about their manufacture and applications is available from Keystone Carbon Co. (3-116)

Bronze Bearings

An outline of the Johnson general purpose bronze bearings, electric motor service bearings, self-lubricating bearings and bronze bars, and of the manufacturers' service facilities is given in a 4-page folder of Johnson Bronze Co. (3-115)

Plastics

The timely advantages of plastics in present-day design problems are emphasized in the new "1 Plastics Avenue" booklet on Textolite, published by General Electric Co., Plastics Department. (3-114)

Prefabricated Steel Housings

The design features and applications of "Lindsay Structure" prefabricated all-steel housings for furnaces, ovens, machines, etc., which entail no welding or riveting, are presented in a pocket-size 16-page bulletin of Dry-Zero Corp. (3-113)

Die List for Porous Bearings

Bound Brook Oil-Less Bearing Co. has issued a 12-page die list on Compo oil-retaining porous bronze bearings, covering available sizes of sleeve, flanged and thrust bearings. (3-112)

"Prefinished" Plated Aluminum

A 4-page folder of American Nickeloid Co. describes (with actual samples) prefinished nickel- and chromium-plated aluminum sheet, ready for fabrication without finishing by the purchaser. (3-111)

Wire Mesh Baskets

"Wire Mesh Baskets for Industrial Use" is the title of a handsome 16-page booklet of Rolock, Inc. Metals available, basket designs, and applications in cleaning, pickling, plating, brazing, quenching, etc., are reviewed. (3-110)

Non-Metallics in Engineering Design

A highly-interesting 8-page bulletin of Continental Diamond Fibre Co. describes 5 types of plastics (and parts made from them) that are of interest to designers seeking non-metallic parts to replace or supplement metals in mechanical and electrical units. (3-106)

Alloy Castings for Furnaces

Literature of Trenite Corp. describes and illustrates this company's alloy castings for heat-resisting service in furnaces, ovens, heaters, pots, etc. and cites service and performance records with them. (3-103)

Plastics in the Emergency

To assist engineers faced with metal-supply difficulties, Monsanto Chemical Co. has prepared a special report on plastics as replacement materials, together with a list of molders and fabricators. (3-96)

Plastics in Product Design

The extent to which plastics may advantageously supplement or replace metals in various familiar modern products is discussed in an unusually interesting 24-page booklet entitled "It's a New Business Custom" published by Durez Plastics & Chemicals, Inc. (3-93)

Powder Metallurgy Products

An interesting outline of the advantages and limitations in making products by powder metallurgy and of Powder Metallurgy Inc.'s contract manufacturing service is given in a leaflet of that company. (3-89)

Ductile Iron Castings

An interesting discussion of Z-Metal—a specially-treated, ductile alloy cast iron—is presented from the engineering viewpoint in a 10-page booklet of Ferrous Metals Corp. Comparisons with steel forgings, steel castings, malleable iron castings, etc., are included. (3-57)

New Corrosion-Resistant Material

"Tygon," a new construction-material (non-metallic) unaffected by nearly all corrosive acids and alkalies, can be used as a lining for tanks, produced as flexible sheets, tubes or molded products, or applied in liquid form, as a protective coating, according to an informative bulletin of U. S. Stoneware Co. (3-95)

Electrical Contacts

A new 16-page catalog illustrating and describing Gibsiloy electrical contacts made from powdered metals has been issued by Gibson Electric Co. and covers 8 standard silver-base contact materials. (3-76)

Bimetals and Electrical Contacts

H. A. Wilson Company's Blue Book of thermometals and electrical contacts contains 48 pages of useful, illustrative, engineering information of aid to designers in the selection of metals and alloys for these applications. (3-70)

Wear Resistant Precious Metal Parts

Permo Products Corp. has issued a bulletin describing Permo metal, a smooth wear-resistant, corrosion-resistant alloy of osmium, rhodium and ruthenium, said to be useful for instrument bearings, fountain pen tips, phonograph needles, contacts, etc. (3-65)

Metal for Cast-to-Form Dies

A 4-page illustrated booklet gives data on the properties and performance of Meehanite for cast-to-form dies. Meehanite Research Institute. (3-64)

Self-Lubricating Bearings

An attractive, interesting and highly useful 16-page catalog of R. W. Rhoades Metaline Co., Inc. discusses Metaline "oilless" bronze bearings, and includes engineering data and illustrations of many applications. (3-46)

Alloys for Heat and Corrosion Resistance

A well-illustrated interesting 8-page bulletin of Duraloy Co. gives useful engineering data and typical applications for Duraloy chromium-nickel, chromium-iron and nickel-chromium heat and corrosion resistant alloys. (3-28)

CONTINUED NEXT PAGE

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Thermostatic Bi-Metal

Complete information on Dole thermostatic bi-metal, in the form of spirals, coils, strips, sheets, prefabricated parts or complete assemblies is offered by Dole Valve Co. (3-44)

Pressure Vessel Fittings

Descriptive and price information on Lenape Hydraulic Pressing & Forging Company's seamless welding necks and other fittings for pressure vessels and kindred fabricated structures is given in a comprehensive catalog. (3-41)

4. MELTING · REFINING · CASTING

(See also Section 6)

Reclaiming Scrap Metal

A scrap-metal reclaimer, which transforms waste-metal—skimmings, sweepings, etc.—to clean-metal ready for re-melting, is described in a bulletin of interest to foundrymen and others seeking to eliminate metal-waste. Dreisbach Engineering Corp. (4-63)

Ferro-titanium and Other Alloys

A pocket-size 12-page booklet of Titanium Alloy Manufacturing Co. reviews in some detail the various T A M alloys and products of interest to metallurgical engineers. These include ferro-titanium of various grades, silico titanium, manganese titanium, nickel titanium, molybdenum titanium, titanium carbide, titanium aluminum, copper titanium, titanium metal and various zirconium alloys (4-56)

Desulphurizer for Molten Iron

Hennig's "purifier and desulphurizer"—a sodium-carbonate-base compound—for desulphurizing and scavenging molten iron in the cupola, air furnace or ladle, is the subject of an 8-page booklet of Pittsburgh Plate Glass Co., Columbia Chemical Div. (4-51)

Exothermic Alloying Agent

The operating and metallurgical benefits resulting from the use of Chrom-X, a chromium-addition alloy that reacts exothermically and does not cool the iron or steel bath, are discussed in literature of Chromium Mining & Smelting Corp. (4-47)

Core Binder

Two publications of Hercules Powder Co.—the first a description of Truline binder and its applicability, with comparative data for other binders, and the second a brochure outlining "What Hercules Is Doing for the Foundry"—are offered. (4-32)

5. HEAT TREATMENT · HEATING

(See also Section 6)

Gas and Air Scrubbers

Information on Peabody Scrubbers for cleaning or drying air or gas, in any quantities and to any degree of cleanliness, is available from Peabody Engineering Co. (5-203)

Rotary Hearth Furnaces

Rotary hearth furnaces requiring no conveyor and only one operator are discussed in a 4-page bulletin of Surface Combustion Corp. Specific operating data for 2 types of such furnaces are given. (5-201)

Bright Hardening Furnaces for High-Speed Tools

Bulletin 1019-3A of Sentry Co. describes hardening furnaces employing Sentry Diamond Blocks for maintaining non-decarburizing, non-scaling atmospheres for hardening high-speed steels. (5-202)

Bright Annealing Metal Strip

Controlled atmosphere electric furnaces for bright annealing metal strip on a production scale, with many interesting refinements, are described in illustrated literature of Sargeant & Wilbur. (5-200)

Salt Baths

Arc salt baths for the case hardening and neutral-salt heat treatment of carbon steels, alloy steels, high-speed steels and for the annealing and heat treatment of non-ferrous alloys are briefly reviewed in a 4-page bulletin of Park Chemical Co. (5-199)

Turbo Blowers

Bulletin No. 300 of North American Mfg. Co. gives complete descriptive data and prices on multi-stage and single-stage directly-connected blowers for supplying combustion air to heat treating furnaces, ovens, etc. (5-198)

Tool Furnaces

A 4-page descriptive bulletin of Mahr Mfg. Co. gives construction data, specifications, operating information and a user's experience on Mahr under-fired and under-and over-fired tool furnaces. (5-197)

Box-Type Electric Furnaces

Bulletin HD441 of Hevi Duty Electric Co. presents 4 pages of useful information on the design, construction and applications of electrically heated box-type furnaces for production heat treating. (5-196)

Tempering Furnaces

Tempering and drawing furnaces for tools, dies and small parts, and for heat treatment of light metals, are described in an illustrated 4-page bulletin (No. 83) of Despatch Oven Co. (5-194)

Blowers, Gas Boosters, Etc.

An easy-to-file 8-page folder of Roots-Connersville Blower Corp., describes blowers for providing combustion air to melting and heating furnaces, and inert gas generators for atmosphere heating. (5-192)

High-Temperature Furnaces

Burrell Technical Supply Co. has issued its catalog F-241—a very useful and attractive 32-page presentation of Burrell laboratory-size box, muffle, pit and tube-type furnaces, auxiliaries and controls for temperatures up to 2650 deg. F. (5-186)

Pot Furnaces

Complete descriptive data on the construction, capacities, operation and applications of oil-fired pot type furnaces for hardening and tempering are given in a 4-page bulletin of Stoler & Curll, Inc. (5-184)

Safe Combustion

A readable, well-illustrated 16-page bulletin of Wheelco Instruments Co. provides complete information on the Wheelco Flame-otrol, Model 1101A—a combustion safeguard applicable to the protection of gas burners, oil burners, powdered coal burners and combinations of these fuels. (5-107)

Furnace and Oven Blowers

Specifications and performance data on Sturtevant centrifugal compressors, used for supplying air to furnaces and ovens, are available from B. F. Sturtevant Co. (5-193)

Gas Burners

The Coppus-Dennis Fanmix gas burner and combination Fanmix gas- and oil-burners, which operate on a new principle and for which are claimed highest efficiency and uniformity, are described in an 8-page bulletin of Coppus Engineering Corp. (5-178)

Electric Salt Bath Furnaces

Information on the Upton electric salt bath furnace, a 3-phase unit for salt-bath heat treating, heating for forging, brazing, etc., at temperatures from 250 to 2500 deg. F., is available from Upton Electric Furnace Div., Commerce Pattern Foundry & Machine Co. (5-177)

Rotary Hearth Furnaces

Rotary hearth furnaces for forging, forming and heat treating provide rapid, uniform, economical heating, according to an interesting descriptive 12-page bulletin of Lee Wilson Sales Corp. (5-176)

Gas-Fired Oven Furnaces

Some interesting construction and operating features of Wall-Trent Model W oven-type furnaces, designed for rapid, scale-free heat treatment at temperatures between 400 and 1800 deg. F., are revealed in a 4-page bulletin of Trent Engineering Laboratories. (5-175)

Blowerless Furnaces

An 8-page booklet of Baker & Co. describes and illustrates gas-fired furnaces operating at 1850-2450 deg. F. without blower or compressed air, and used for treating high-speed steel, hardening tools and dies, fluxless brazing and other production jobs. (5-168)

Blower for Oil Burning

The type "G" Motor Blower, a new blower for oil-burning furnaces, is described as providing reliable service, maintaining constant pressure, and saving power costs, in an 8-page engineering bulletin of Ingersoll-Rand. (5-154)

Balanced Carburizing Baths

Descriptive bulletins on Aerocarb and Aerocase baths and the 2 component principle for achieving balanced case hardening mixtures have been issued by American Cyanamid & Chemical Corp. (5-135)

Electric Tempering Furnaces

Cyclone box-type electric furnaces for accurate tool-room tempering, production tempering and other quality heating applications are described and illustrated, with specifications, in a 4-page bulletin of Lindberg Engineering Co. (5-130)

High Frequency Converters

High frequency electric converters for use in conjunction with numerous industrial induction heating applications are described. Lepel High Frequency Laboratories, Inc. (5-124)

Electric Pot Furnaces

Cylindrical electric pot furnaces (Model P), for lead, salt and cyanide bath treatment are discussed in a 2-page bulletin of American Electric Furnace Co. (5-97)

Lithium-Atmosphere Furnace

The operating principle, constructional features and performance of the new Lithco atmosphere furnaces, claimed to provide inexpensive heat treating without scaling or decarburization, are described in a 6-page bulletin of Lithium Corp. (5-115)

Heat Treating Furnaces

An unusually comprehensive, well-illustrated 24-page broadside of Leeds & Northrup Co. gives practical operating and engineering data and a wealth of descriptive material on L. & N furnaces for carburizing, tempering, hardening and nitriding. (5-106)

Combustion Control System

The Isley system of regenerative furnace combustion control and its application to soaking pits, slab, bloom and billet heating furnaces, and forging furnaces, are discussed in an illustrated 8-page bulletin. Morgan Construction Co. (5-89)

Ingot Soaking Pits

Amsler-Morton Co. has issued a comprehensive 24-page bulletin describing Amco pit furnaces and their applications, and offering a series of 6 case histories selected to show the unusual service requirements successfully fulfilled. (5-81)

Bright Annealing

Profusely illustrated 8-page bulletin describes many types of furnaces—electric and fuel-fired—for bright annealing ferrous and non-ferrous metal products. Electric Furnace Co. (5-44)

Control of Furnace Atmosphere

Two bulletins devoted to a description of "Certain Curtain Control of Atmosphere" and to furnaces for pre-heating and hardening high-speed steel have been issued by C. I. Hayes, Inc. (5-33)

6. REFRACTORIES • INSULATION

Basic Refractories

A beautiful 16-page brochure containing several interesting and dramatic operating photographs describes the resources and facilities of Basic Refractories, Inc., formerly Basic Dolomite, Inc. (6-59)

High-Temperature Insulating Block

Coprtex and High Strength Coprtex blocks and Coprtex cement, all used for back-up insulation in furnaces, ovens, etc., are described with engineering data in a 4-page bulletin of Armstrong Cork Co. (6-58)

Vitreous Silica Pipes, Fittings

Standard shapes and special designs of Vitreosil (vitreous silica) non-porous ceramic pipes, bends and other fittings for high temperature or corrosion-resisting equipment are described in a 4-page bulletin of Thermal Syndicate, Ltd. (6-50)

Heavy Duty Refractories

A highly readable and informative new catalog, "Super Refractories by Carborundum," offers 76 pages of beautifully illustrated information on the properties and applications of the silicon carbide, fused aluminum oxide, mullite, and aluminum silicate refractories and cements manufactured by Carborundum Co. (6-45)

Low-Cost Insulating Brick

A leaflet of Illinois Clay Products Co. describes their Therm-O-Flake brick, an insulating brick of extra light-weight claimed to have high resistance to handling losses. Properties and uses are featured. (6-48)

Super Refractories

Catalog No. 301 of Chas. Taylor Sons Co. is replete with useful data on P. B. Sillimanite refractories for use up to 3300 deg. F. in electric furnace roofs and linings, induction furnaces, crucible furnaces, fuel-fired hearths, piers and linings, burner blocks, etc. (6-16)

7. WELDING • CUTTING • BRAZING

Spot Welding Timers

Ignitron spot welding timers to control the welding of aluminum, heat treated alloys and other materials are described in a new leaflet (18-335) of Westinghouse Elec. & Mfg. Co. Applications, design features and operating details are included. (7-77)

Thermit Welding

An unusually interesting and attractive 36-page booklet of Metal & Thermit Corp. describes the Thermit welding process and its application with much engineering data and many illustrations. The use of the process for fabricating heavy machine parts is described. (7-76)

Oxyacetylene Welding and Cutting

A 12-page illustrated booklet of Linde Air Products Co. discusses the oxyacetylene process and describes welding and cutting apparatus used. (7-75)

Low-Temperature Brazing Alloys

Sil-Fos and Easy-Flo—fast-acting, low-temperature, high-strength brazing alloys—are presented as "The Minute Men of Metal Joining" in an interesting 4-page bulletin of Handy & Harman. (7-65)

8. FORMING • FORGING • MACHINING

Disc Grinding

The Norton Co. has issued an instructive 32-page manual on disc grinding, including plate-mounted cylinders. Recommendations for wheels and abrasives for many types of operations and materials are given. (8-81)

Hydraulic Presses

Large and small hydraulic presses for metal-forming, deep drawing, stamping, forging, straightening, etc., are the subject of a handsome, usefully illustrated 16-page bulletin of A. B. Farquhar Co., Ltd. (8-80)

Powder Metallurgy Presses, Molds

Several pages of descriptive information about large and small molds and presses for briquetting powdered metals are available from F. J. Stokes Machine Co. (8-54)

Please Use the Coupon on Page 703

Carbide Cutting Tools

A 32-page catalog (No. 41) of McKenna Metals Co., lists specifications and prices for Kennametal steel-cutting tools and blanks—5 styles of blanks, 28 standard tools, several semi-standard tools, etc. (8-78)

Bending Rolls

Buffalo Forge Co. describes in their 20-page bulletin, No. 352-A, their various types of vertical, horizontal, simplex and pinch-type bending rolls and their use for circle, segment and spiral bending of angles, tees, channels, etc. (8-74)

Bearing and Gear Lubrication

Bulletin No. 5 of D. A. Stuart Oil Co., Ltd. contains 12 pages of useful descriptive information on Sturaco extreme pressure oils and greases for bearing surfaces and gears on metal-working and other industrial machinery. (8-71)

Cutting Oils

Cities Service Oil Co. has published a comprehensive, readable bulletin on the theory and practice of metal cutting lubrication. Types of lubricants and their intelligent application are discussed. (8-19)

9. CLEANING • PICKLING • PLATING FINISHING

Blackening Steel

A folder of E. F. Houghton & Co. describes the Houghto-Black process for rapidly blackening steels by simple immersion. (9-108)

Spray-finishing Systems

Standard spray-painting and spray-finishing equipment such as spray guns, compressors, circulating systems, respirators and spray booths are described and illustrated in a 28-page catalog (IE) of DeVilbiss Co. (9-107)

Plating-Tank Instrumentation

A new system of instrumentation for electroplating tanks, based on direct control of heating-water temperature, is described in a bulletin (81-2) of Brown Instrument Co. (9-106)

Corrosion Protection

This handbook reviews the principles of corrosion protection and discusses the composition, protective value and specific applications of several types of protective coatings offered by Alox Corporation. (9-92)

Corrosion Resistant Ceramics

Acid- and alkali-proof cements, plastic linings, mortars and protective coatings applicable to electrorefining tanks, plating departments, pickling equipment and metal coating and joining applications are completely described in a 15-page bulletin of Atlas Mineral Products Co. (9-72)

Pickling Agent

An attractive and useful 12-page booklet is devoted to Ferrisul, a soluble ferric sulphate claimed to be specially useful for pickling stainless steel and copper alloys and for etching steel before galvanizing or tinning. Merrimac Div., Monsanto Chemical Co. (9-63)

(MORE LITERATURE ON PAGE 706)

Blackening Iron and Steel

An interesting folder of Alrose Chemical Co. describes the Jetal process for producing a lustrous, jet black, rust-resistant finish on steel parts by simple immersion. (9-95)

Metal-Decorating Oven

Bulletin No. 126 (12 pages) of J. O. Ross Engineering Corp. describes, with many illustrations, the Ross metal-decorating oven used for baking all kinds of fine finishes on metals and metal-products. (9-91)

Electrochemical Descaling

The characteristics of the Bullard-Dunn electrochemical process for removing scale and oxides from metals, its operating factors and some important applications are discussed in an 8-page bulletin of Bullard-Dunn Div., Bullard Co. (9-88)

Plating Chemicals and Processes

E. I. duPont de Nemours & Co., Inc., Electroplating Div., offers a very useful 16-page booklet reviewing the various electroplating processes, cleaning methods, and pickling procedures with respect to their applications and to the chemicals and other materials used in them. (9-82)

Electroplating Generators

Advanced design features permitting light weight, compact size, more efficient performance and continuous operation are claimed for the low-voltage (6-60 v.) generators of Columbia Elec. Mfg. Co. in their literature. (9-79)

Airless Blast Cleaning

A colorful 4-page folder of Pangborn Corp. reports on the advantages and applications of Rotoblast airless blast cleaning units for castings, forgings and other large and small metal parts. (9-73)

Concentrated Industrial Cleaners

An interesting 8-page folder on Pennsalt cleaners applicable to ferrous and non-ferrous materials and painted surfaces before finishing operations has been issued by Pennsylvania Salt Mfg. Co. Uses in various industries and guides to cleaner selection are indicated. (9-46)

10. TESTING • INSPECTION • CONTROL

X-ray Film

Literature giving the exposure and processing factors and the applications in metal-part inspection of Eastman X-ray film is offered by Eastman Kodak Co. (10-170)

Balancing Machines

Static and dynamic balancing machines are comprehensively presented in an unusually interesting and attractive 54-page catalog of Tinius Olsen Testing Machine Co. The need for determining balance in machinery design and construction and the metal-correctives to be applied are explained. (10-169)

Potentiometer Controllers

A new 8-page folder of Foxboro Co. emphasizes the "group drive" feature of Foxboro potentiometer controllers and illustrates their many applications in the control industries. (10-168)

Radium for Radiography

A 20-page bulletin of Canadian Radium & Uranium Corp. discusses the uses and advantages of radium for radiographic inspection of metals, and outlines this company's services. (10-167)

Control Valves

A readable and useful 24-page catalog (No. 77-1) of Brown Instrument Co. completely describes Brown and Minneapolis-Honeywell motor-power units and motorized valves for furnace control systems. (10-166)

Strip-Chart Recorders

A 16-page bulletin (No. 570) on the strip-chart recorders recently developed by Bristol Co. is available, with full design, construction and application information. (10-165)

X-Ray Machines

Westinghouse X-Ray Co., Inc., offers descriptive information on X-ray equipment for inspection of castings, welds, etc., and on its applications in industry. (10-164)

Portable Potentiometer Pyrometer

A 4-page bulletin of Lewis Engineering Co. describes and illustrates a "pocket-size" portable pyrometer potentiometer, with complete data on design, construction, accessories, performance, etc. (10-163)

Microhardness Tester

A microhardness tester and accessories for determining the hardness of microstructural areas of metal surfaces are described in a folder of Eberbach & Sons Co. (10-156)

Portable Brinell Hardness Tester

A new portable Brinell hardness tester, which weighs less than 26 lbs. and makes a standard test with 3,000-kg. load and 10-mm. ball, is described in a 4-page bulletin of Andrew King. (10-148)

Universal Testing Machines

A 4-page bulletin of Riehle Testing Machine Div., American Machine & Metals, Inc., describes improvements in the Model 505 Universal hydraulic testing machines, of up to 60,000 lbs. capacity, for compression, tension and transverse testing. (10-144)

Flue Gas Analyzer

According to a descriptive 8-page bulletin of Chas. Engelhard, Inc., the Flualyzer is a portable, light-weight, reliable instrument that accurately measures the temperature and CO_2 content of flue gas and thus aids in controlling combustion. (10-143)

Measuring Coating Thickness

The Aminco-Brenner Magne-Gage for the rapid non-destructive measurement of plated and other metal coatings is described in a bulletin of the American Instrument Co. (10-118)

New Illuminated Magnifier

The Pike-o-Scope, an electrically illuminated magnifier said to be useful for all general inspections is described in a leaflet of E. W. Pike & Co. (10-58)

Please Use the Coupon on Page 703

Sheet Metal Dial Micrometer

The Haines "one-hand" dial micrometer, featuring accuracy, easy-readability and simplicity of operation, is used for checking steel and non-ferrous sheet thicknesses in producer's mills, fabricator's shops, warehouses, etc., according to a 4-page folder of Haines Gauge Co. (10-140)

Testing Equipment

A rapid-fire, informative summary of Baldwin-Southwark Division's testing, inspection, recording and control equipment, with an index of available descriptive literature by this company is contained in a 6-page leaflet. (10-121)

Salt Spray Test Containers

The unique advantages of long-lived, compact Alberene stone containers for salt spray corrosion testing equipment are presented in literature of Alberene Stone Corp. of Va. (10-120)

Metallographic Polishing Equipment

The new Jarrett metallographic polishing machine, said to be almost completely automatic, and the Jarrett specimen mounting press are described in literature of Tracy C. Jarrett. (10-117)

Photomicrographic Equipment

A very interesting 28-page catalog of Bausch & Lomb Optical Co. discusses the basic factors in photomicrography, and describes and illustrates in useful detail a variety of metallurgical microscopes, cameras and optical equipment. (10-90)

Radium for Metal Inspection

The use of radium for the radiographic examination of castings, welds, and other forms of metal to establish their quality is described, with complete data on industrial practice, in a technical pamphlet issued by Radium Chemical Co., Inc. (10-81)

Metallurgical Testing Apparatus

The latest edition of *The Metal Analyst*, just out, contains 98 pages of highly useful and attractively presented information on metallographic and metallurgical testing equipment, spectrographic apparatus and optical instruments, and a 1053-reference bibliography on relevant technical publications. Adolph I. Buehler. (10-80)

Tensile Testing Fine Wire

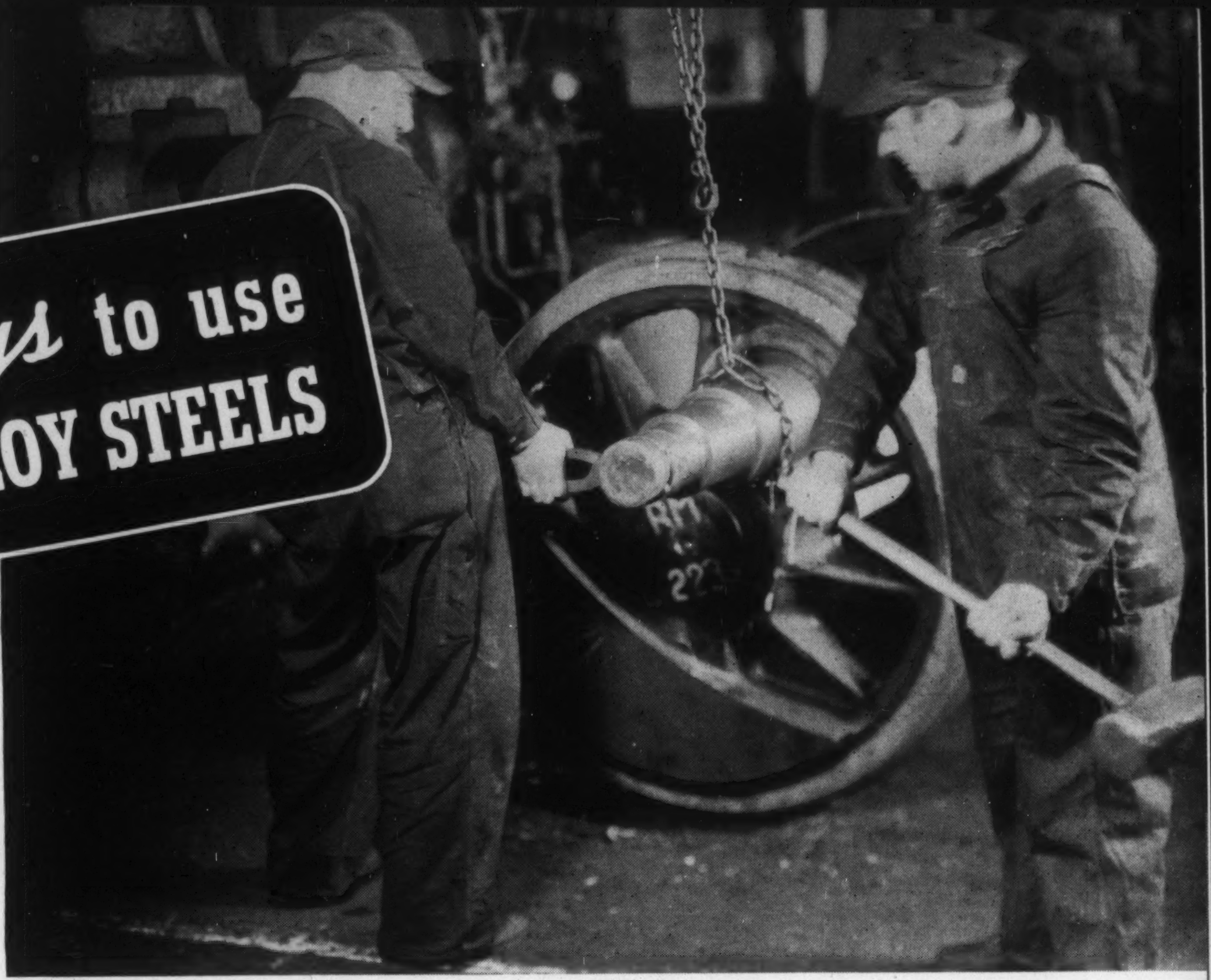
Henry L. Scott Co. has reprints available of an article in METALS AND ALLOYS on methods and equipment for testing the tensile strength, elongation, yield point, etc., of fine wire used for weaving, radio tubes and other applications where absolute uniformity is imperative. (10-55)

Pyrometer Control

The Alnor electronic pyrometer controller is completely described as to construction, operation, installation wiring and applications in a 4-page booklet of Illinois Testing Laboratories, Inc. Some of the applications illustrated are very interesting because of their "special" nature. (10-42)

The X-Ray in Industry

The application of X-ray examination and inspection to castings and welds and of X-ray diffraction to studies of internal changes in metals during cold working, etc. is exhaustively covered in this 35-page catalog, replete with illustrations. General Electric X-Ray Corp. (10-10)



Setting crank pin of Republic Alloy Steel in a locomotive drive wheel, preparatory to pressing it in.

When it *pays* to use REPUBLIC ALLOY STEELS

REPUBLIC STEEL DEFENSE FOR AMERICA

LET'S KEEP COOL!

If our American way of life is to survive, every industry must work in close cooperation with the industries that serve it and, in turn, with the industries it serves during this period of peak demand for goods.

A rush for materials is very much like a run on a bank—and can be equally dangerous unless cool heads analyze and plan.

We, in Republic, are doing just that—analyzing the orders we receive and planning our production, so that our greatly enlarged blast furnace, electric furnace and rolling mill facilities can be as helpful as possible to the greatest number of buyers in serving America's urgent need for ***steel—first line of national defense.***

R. J. Wysor
PRESIDENT

In considering the kind of material to use for a metal part in any particular class of service, an economic balance must be struck between the first cost and the subsequent costs of repairs, replacements, and the attendant down-time costs. Those parts which do not require great strength, high fatigue properties, deep hardness, high creep resistance, extreme corrosion resistance or toughness at sub-zero temperatures can be constructed of plain carbon steels. However, as these qualities increase in importance, the need for Republic Alloy Steels becomes more and more imperative—and their use more economic.

Bring your material problems to Republic
—world's largest makers of alloy steels.

REPUBLIC STEEL CORPORATION
Alloy Steel Division: Massillon, Ohio • General Offices: Cleveland, Ohio
BERGER MANUFACTURING DIVISION • CULVERT DIVISION • NILES STEEL PRODUCTS DIVISION
STEEL AND TUBES DIVISION • UNION DRAWN STEEL DIVISION • TRUSCON STEEL COMPANY

—REPUBLIC—*Alloy Steels*

DRAW ON THIS STORE OF USER EXPERIENCE TO SPEED DEFENSE

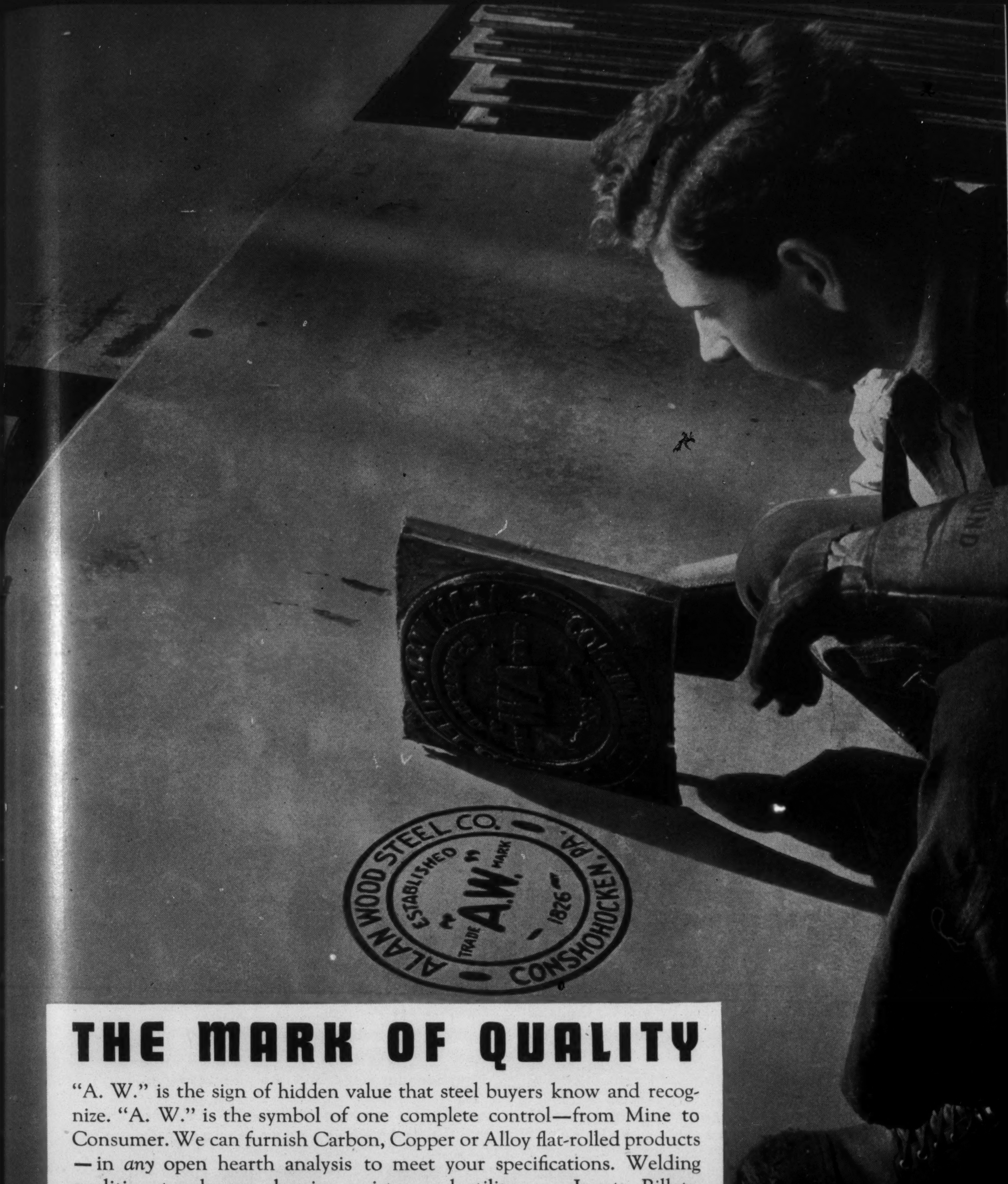
To assist manufacturers and engineers in finding practical solutions to problems involving the selection, treatment, fabrication and use of alloys containing Nickel, The International Nickel Company, Inc. have compiled essential facts based on years of research and field studies. These facts are condensed into convenient printed form.

Also available for consultation is a staff of experienced engineers—men who have cooperated for years with producers and manufacturers—helping to work out solutions for a wide range of metallurgical problems.

Now—when minutes and materials are so vital to defense efforts—make full use of this service. Send for a check list of helpful publications, or submit your specific problem to:

NICKEL

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET
NEW YORK, N. Y.



THE MARK OF QUALITY

"A. W." is the sign of hidden value that steel buyers know and recognize. "A. W." is the symbol of one complete control—from Mine to Consumer. We can furnish Carbon, Copper or Alloy flat-rolled products —in *any* open hearth analysis to meet your specifications. Welding qualities, toughness, abrasion resistance, ductility . . . Ingots, Billets, Blooms, Slabs, Sheared Plates, Hot Rolled Sheets. Floor Plates for every flooring need. Steel Cut Nails in all types and sizes. "Swede" Pig Iron — Foundry, Malleable, Basic, Bessemer. "A.W." Products have been an accepted standard for steel buyers for more than a century.

ALAN WOOD STEEL COMPANY, CONSHOHOCKEN, PA.

SINCE 1826 : : DISTRICT OFFICES AND REPRESENTATIVES — Philadelphia, New York, Boston, Atlanta, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Houston, New Orleans, St. Paul, Pittsburgh, Roanoke, Sanford, N. C., St. Louis, Los Angeles, San Francisco, Seattle, Montreal.

. . . Molybdenum makes possible heat check resistant base iron brake drums

Heat checking usually causes failure of cast iron brake drums on buses — trucks — airplanes — railway equipment. Meeting the situation by raising the total carbon is often incompatible with the strength requirements.

Adding about 0.50% Molybdenum permits both a higher total carbon and the required strength. Chromium and vanadium additions help improve the high temperature strength.

Write for technical book "Molybdenum in Cast Iron" for details on brake drum irons and other Molybdenum irons and their applications.

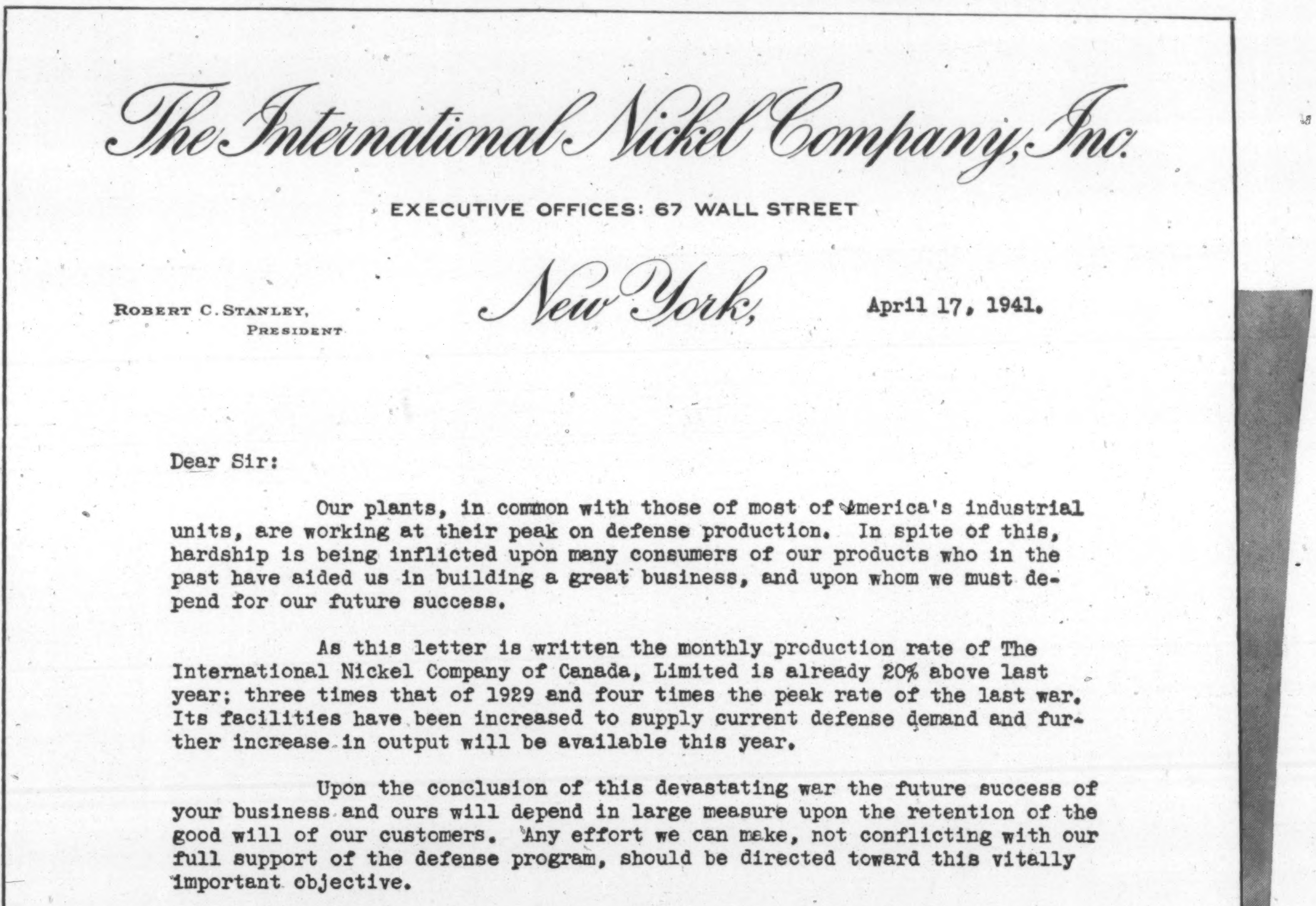
CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.
MOLYBDIC OXIDE BRIQUETTES FOR THE CUPOLA—FERROMOLYBDENUM FOR THE LADLE

MOLY

Climax Mo-lyb-den-um Company
500 Fifth Avenue · New York City

DEFENSE AND THE FUTURE...

Copy of Letter to users of Products of The International Nickel Company, Inc.



The International Nickel Company, Inc.

EXECUTIVE OFFICES: 67 WALL STREET

ROBERT C. STANLEY,
PRESIDENT

New York,

April 17, 1941.

Dear Sir:

Our plants, in common with those of most of America's industrial units, are working at their peak on defense production. In spite of this, hardship is being inflicted upon many consumers of our products who in the past have aided us in building a great business, and upon whom we must depend for our future success.

As this letter is written the monthly production rate of The International Nickel Company of Canada, Limited is already 20% above last year; three times that of 1929 and four times the peak rate of the last war. Its facilities have been increased to supply current defense demand and further increase in output will be available this year.

Upon the conclusion of this devastating war the future success of your business and ours will depend in large measure upon the retention of the good will of our customers. Any effort we can make, not conflicting with our full support of the defense program, should be directed toward this vitally important objective.

To this end we wish to offer our services especially to those customers whose requirements cannot for the moment be filled. One practical means of rendering such service is to offer you the assistance of our technical staff in solving problems of material arising from the temporary lack of nickel.

Our problems are complex and constantly changing and can only be solved through cooperation. As we see it, a large part of the solution lies in making clear the situation which we face. Your help and advice will be of invaluable assistance. It is our purpose to follow this letter with a personal call from one of our representatives, if you so desire, who will discuss with you in more specific detail our mutual problems.

Yours very truly,

PRESIDENT.

RCS:JJS

ALUMINUM, DEFENSE, AND YOU

3

IT IS EASY TO UNDERSTAND ABOUT ALUMINUM AND DEFENSE

THE WHOLE THING BOILS DOWN to two simple questions:

1. **How much aluminum** are America and England going to need?

   There is only one answer: The democracies must have *all the aluminum it takes to win*, and nobody knows how much that is.

2. **How fast** is aluminum needed?

   We don't know, for sure, but just as fast as the aircraft plants, munition plants, shipyards, and the like, can be expanded to use aluminum and other materials for defense purposes.

THOSE IN AUTHORITY IN WASHINGTON are putting together, day by day, expert estimates of what all these defense industries are going to need, month by month, clear to the end of 1942. These estimates, as issued, are our book of rules.

FOR MONTHS WE HAVE BEEN, and are now, delivering aluminum for defense purposes far in excess of that called for by prior estimates.

DEFENSE IS NOW TAKING from us over 40 million pounds a month. Every American ought to have a picture of just how much aluminum that is; here it is:

> Peace-time America, during the nine years from 1930-8, could find use for only 14 million pounds a month from us.

In the busy year of 1939 we had to make only 27 million pounds a month to satisfy the civilian needs of this prospering country.

Suddenly, defense alone needs 40 million a month! 14 million (civilian), to 27 (civilian), to 40 (defense) and soon to 50 and beyond!

★ ★ ★ ★

YOU CIVILIAN USERS of aluminum are grand people.

THE WAY YOU ARE DOING WITHOUT aluminum until producers can catch up again with civilian uses is typically American. We are sincerely grateful for your understanding.

IN THIS RECESS you are having to scramble for **RECESSITIES**—other materials which just don't fill the bill 100%, because there is no pat substitute for aluminum.

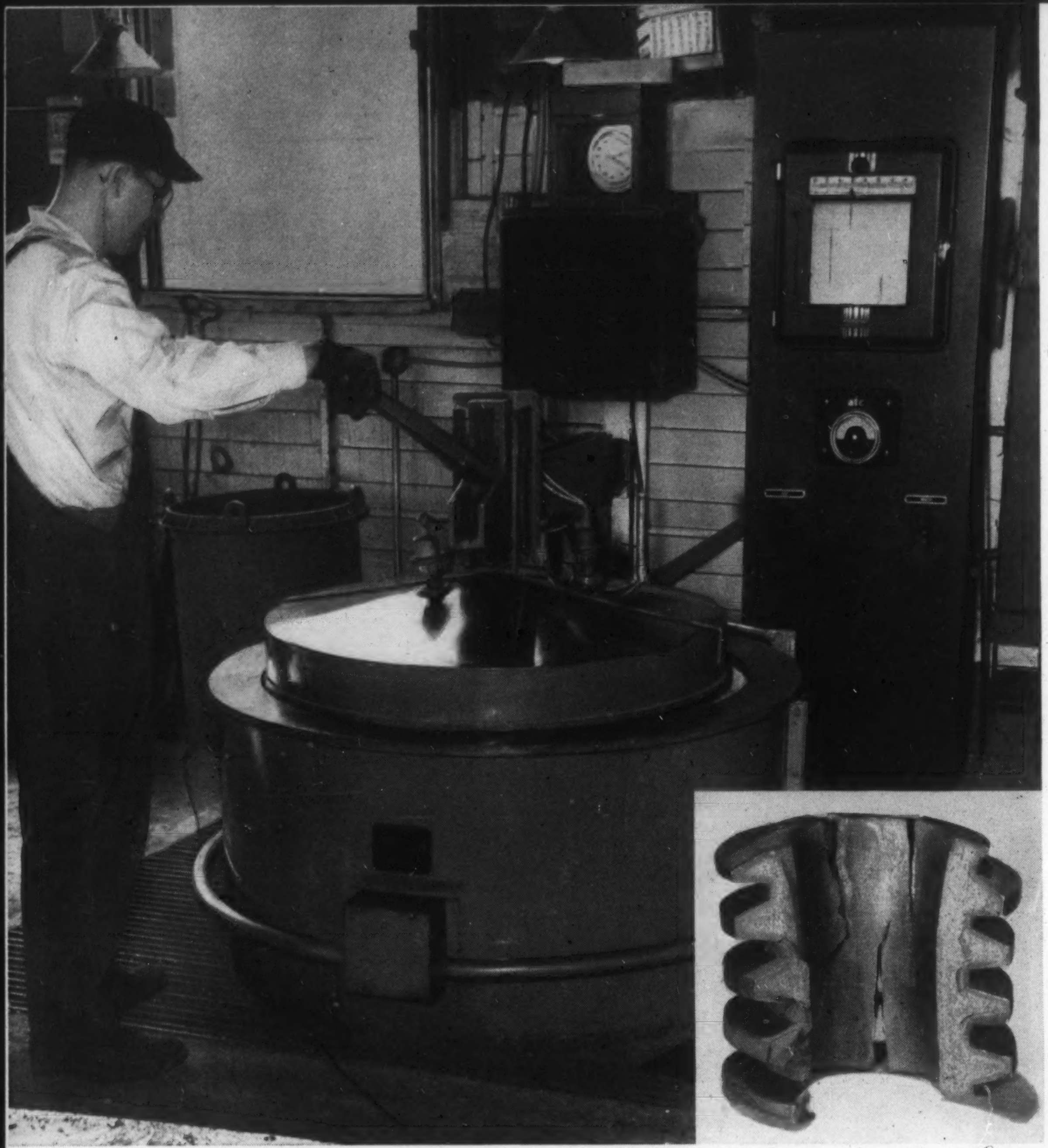
IT'S TOUGH ON YOU and it's hard on us to have to turn away temporarily from the friends and pursuits of a lifetime.

WE HAVE NOT TURNED OUR BACKS!

WE INTEND that no civilian shall have to forego the things aluminum can do best one minute longer than we can help.

ALUMINUM COMPANY OF AMERICA

ALCOA
ALUMINUM



Starting to unload carburized gears from Homo Tempering Furnace, at Boston Gear Works, Quincy, Mass. Insert is gear after tempering, split apart to show structure.

"BOSTON" GEARS DRAWN FASTER, And Better . . . The Homo Way

High quality, mass-production tempering is of course not new to Boston Gear Works Inc. In making their carburized gears they long ago conquered the problems involved. But . . . tempering was never so accurate, so economical or so fool-proof as it became with the use of their *Modern* Homo Method equipment. Boston Gear finds four specific advantages:

1. Tempering is done 50 degrees lower than by their previous method because the Homo's uniform heat makes it unnecessary to overheat some gears in order to be sure of adequately heating the others. Result is greater and more uniform hardness of gears.

2. Uniformity is so high that a very considerable amount of inspecting is eliminated, and re-running is unknown. Result is faster production.

3. Gears are clean and dry when tempered; there's no washing, no expense for oil; no oil fumes or hazard. Results are lower cost and better working conditions.

4. No furnace repairs for months at a time, and then they are minor; "Equipment can certainly take it." Result is that production schedule is held with ease.

See Catalog T-625 for description of Modern Homo Method equipment.

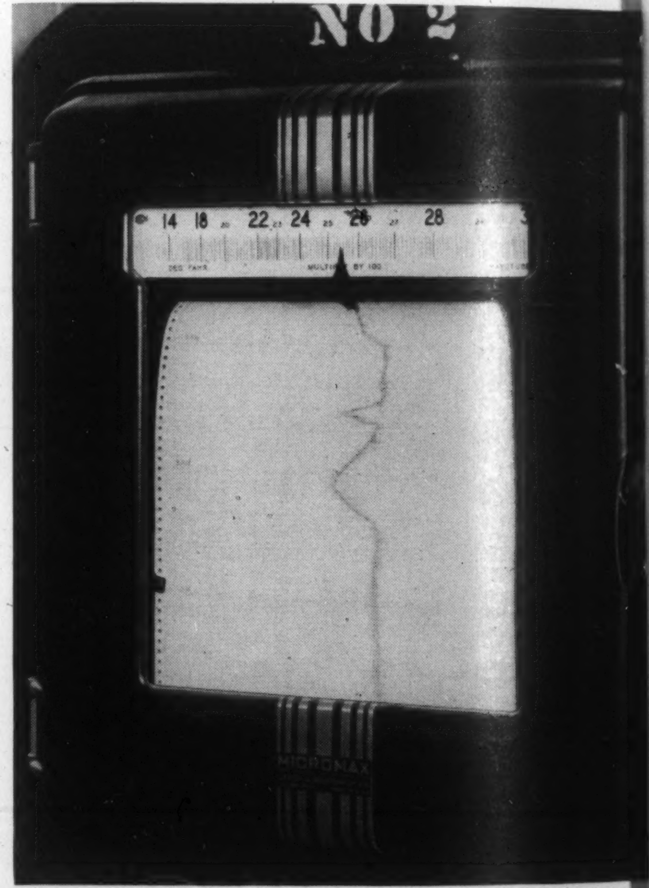
Cement Makers Show Other Users of Rotary Furnaces How To Get Better Control

In commenting on its temperature-control system, the Southwestern Portland Cement Co. has, we think, written something which will interest many other users of rotary furnaces. The high temperature (2700 F) of their burning zone, plus the inevitable dust, plus the enormous size of cement kilns (400 feet long in many cases) combine to create service conditions which instrument-makers call severe. Yet, in spite of these conditions, Southwestern writes as follows:

"We have almost entirely eliminated the guesswork and uncertainty on the part of the kiln operator, as far as temperature is concerned, by the use of Micromax recorders with Rayotubes sighted on the moving clinker.

"It is difficult for even an experienced kiln burner to distinguish a difference of fifty or a hundred degrees, at the high temperature required to burn cement clinker. This is easily accomplished, however, by the use of Rayotubes.

"Another advantage is the protection of the kiln lining. Rayotubes can't prevent all damage, but they help materially in preventing the over-heating which contributes to damage."



Micromax Recorder for Rayotube on cement kiln at Southwestern Portland Cement Co., showing record of temperature of moving clinker.

The above is no isolated case; scores of cement kilns, rotary sludge dryers, rotary heat-treating furnaces, etc., use, with fine results, Micromax recorders or controllers connected, not to the usual thermocouples, but to Rayotubes instead. And this application is by no means limited to rotary furnaces. In general, it includes controlled-atmosphere furnaces, glass tanks, open-hearths, blast furnaces, rolling mills, soaking pits, and many other services. For further information, write for Catalogs.

LEEDS & NORTHRUP COMPANY, 4925 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

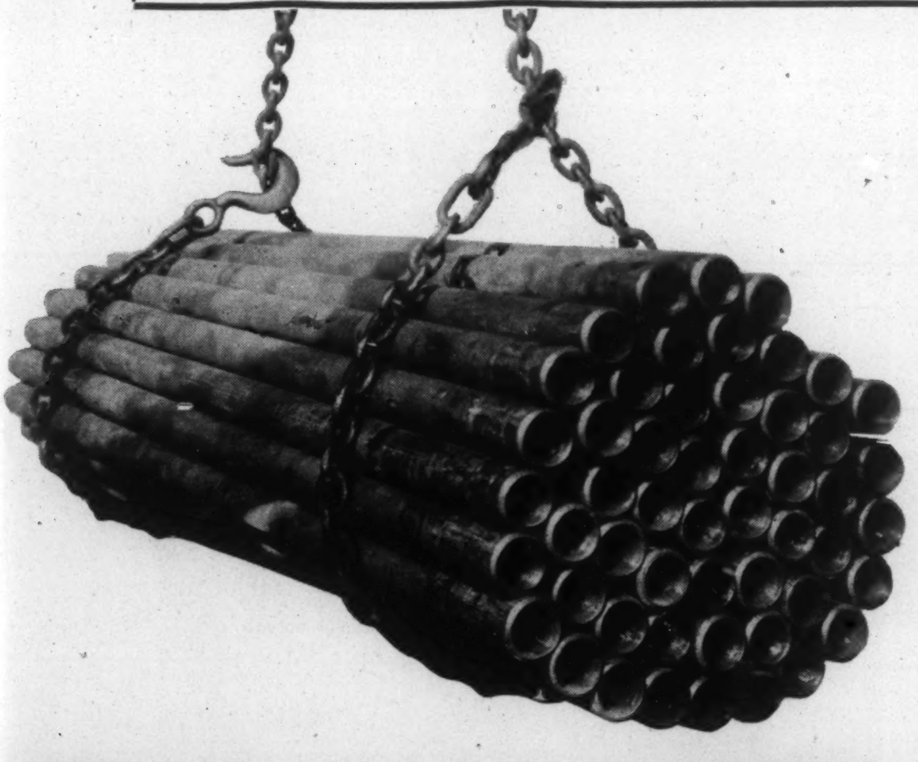
Jrl Ad ENT-0600C(21) **MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES**

DURASPUN CENTRIFUGAL CASTINGS

CHROME-IRON • CHROME-NICKEL

Stronger Metal • True Concentricity • Denser Metal

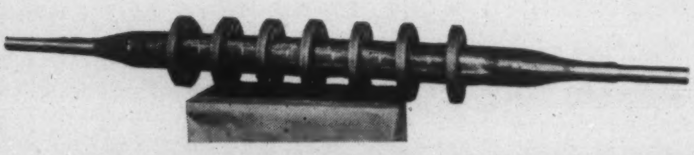
They're Superior for Many Purposes



The use of DURASPUN Centrifugal Castings is increasing by leaps and bounds—not only for tubing but for many other purposes. In fact, there is little to limit the application of centrifugal castings other than that they must have a uniform circular hole through the center. Considerable variations on the outside are permissible.

DURASPUN Centrifugal Castings have been on the market for nearly 10 years—as long as any and longer than most. We pioneered in this work as we did in static castings back in 1922. Sizes range up to 16½ inches in diameter, and up to 13½ feet in length. Wall thicknesses begin at about ¼ inch and increase as diameter increases. Special shapes can be made.

Tell us about your high alloy casting requirements. If you can use centrifugal castings you will get a superior metal for many purposes.



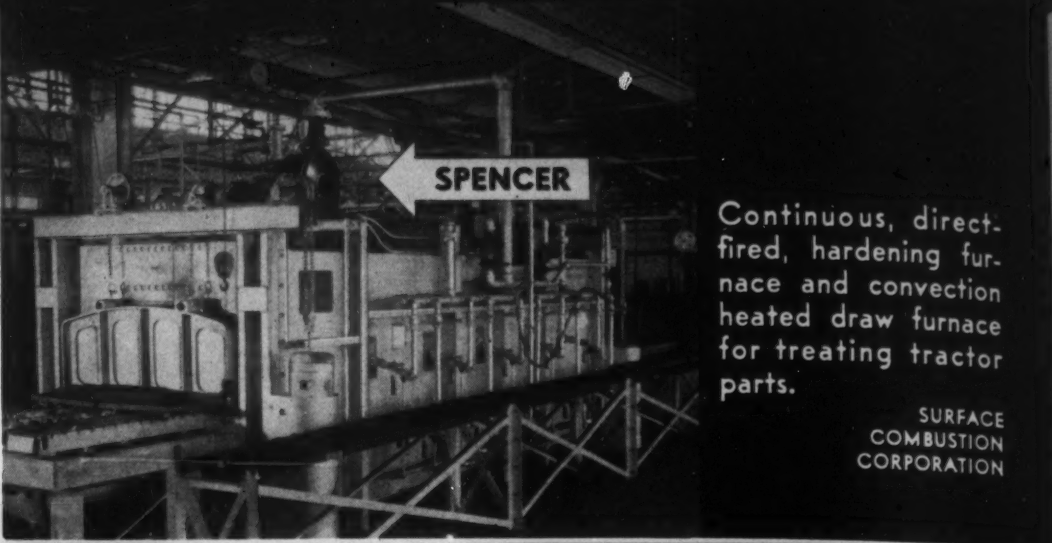
THE DURALOY COMPANY

Office and Plant: Scottdale, Pa.
Eastern Office: 12 East 41st St., New York, N. Y.

Detroit The Duraloy Co. of Detroit	Scranton, Pa. Coffin & Smith	St. Louis Metal Goods Corp.	Los Angeles Great Western Steel Company

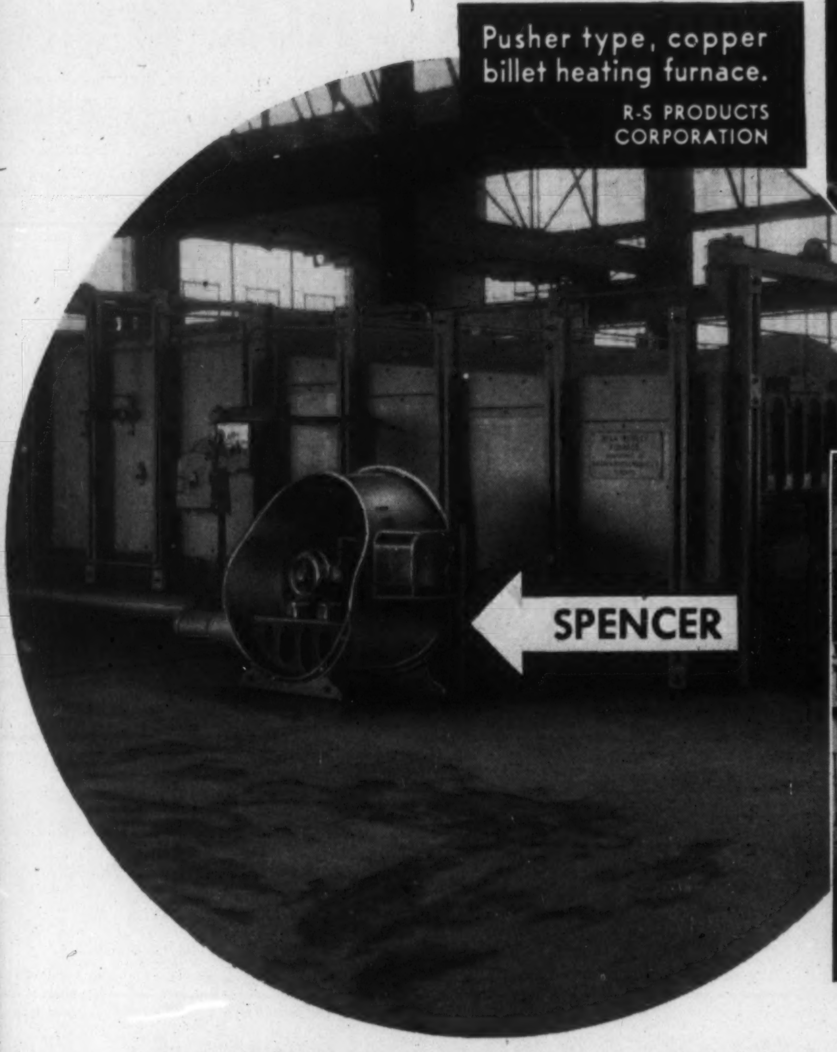
HEAT TREATING

for defense



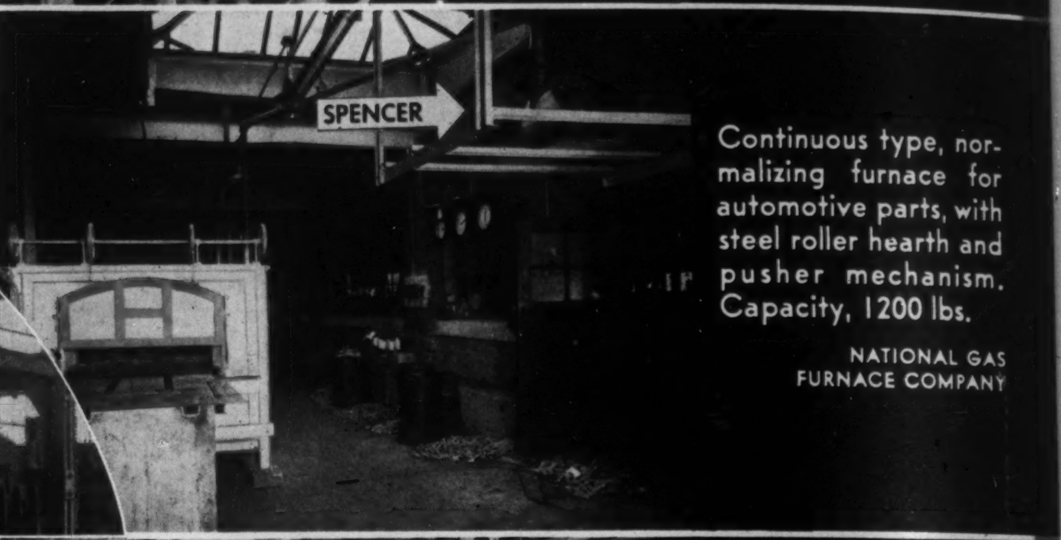
Continuous, direct-fired, hardening furnace and convection heated draw furnace for treating tractor parts.

SURFACE
COMBUSTION
CORPORATION



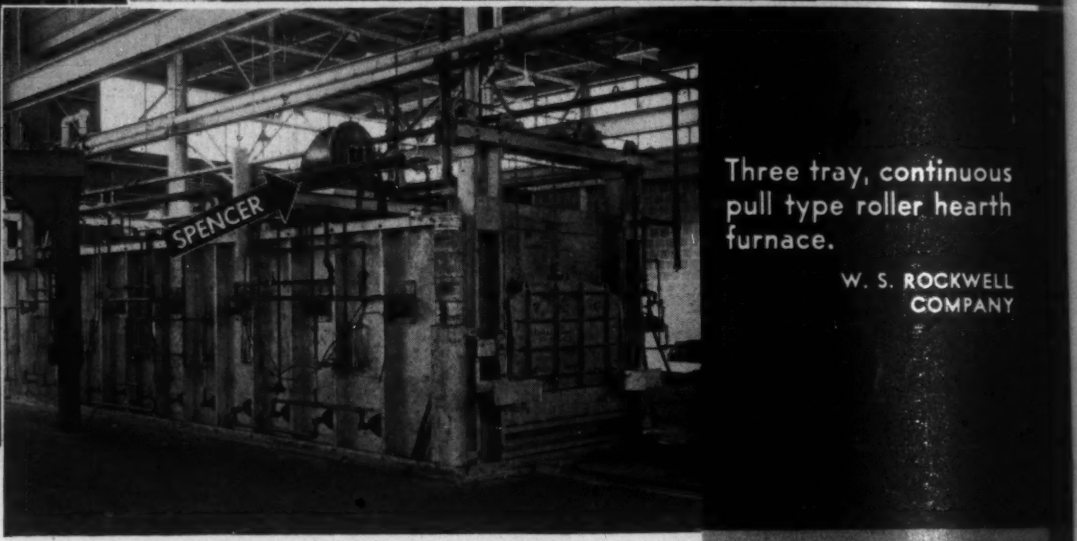
Pusher type, copper billet heating furnace.

R-S PRODUCTS
CORPORATION



Continuous type, normalizing furnace for automotive parts, with steel roller hearth and pusher mechanism. Capacity, 1200 lbs.

NATIONAL GAS
FURNACE COMPANY



Three tray, continuous pull type roller hearth furnace.

W. S. ROCKWELL
COMPANY

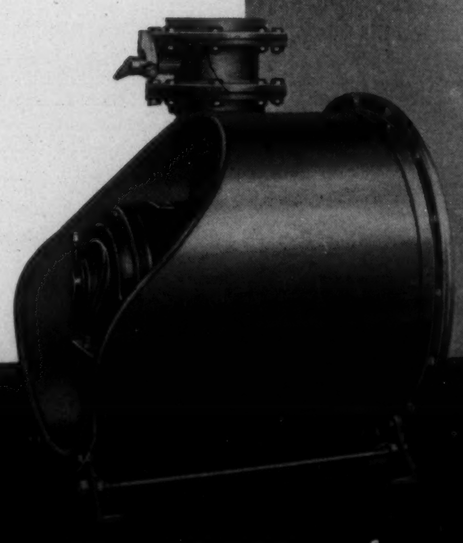
Do any of these heat treating terms suggest ways to speed up and meet your present production difficulties?

"CONTINUOUS"
"BELT CONVEYOR"
"AUTOMATIC"
"ROTARY"
"ATMOSPHERIC CONTROL"
"ROLLER HEARTH"
"ROTARY HEARTH"
"TRIPLE ZONE"

All these terms mean speeding up and better production. All these improvements and many more are available from furnace manufacturers in a modern furnace equipped with a Spencer Turbo for reliable air supply.

WHY NOT ASK YOUR FURNACE MANUFACTURER NOW?

-209-B



FOR
Agitation
Combustion
Exhaustion
Gas Boosters
Ventilation & Cooling
Airplane Testing

SPENCER

HARTFORD

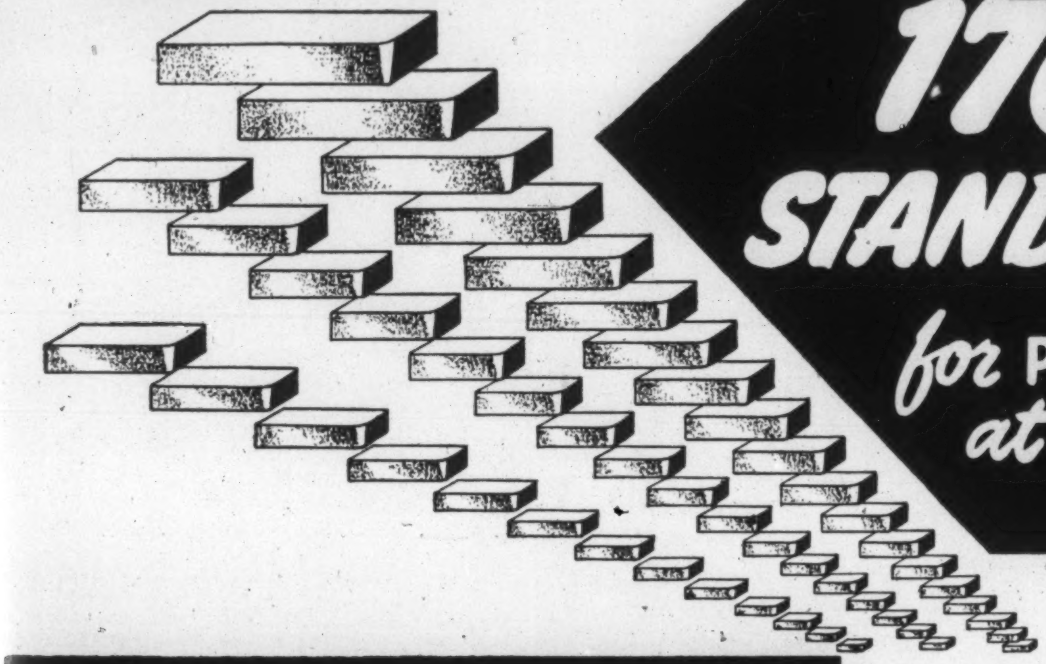
Turbo Compressors

35 to 20,000 cu. ft.
1/3 to 300 H.P.
8 oz. to 5 lbs.

THE SPENCER TURBINE COMPANY • HARTFORD, CONNECTICUT

MORE FIRTHITE TOOL TIPS!

(SINTERED CARBIDE)

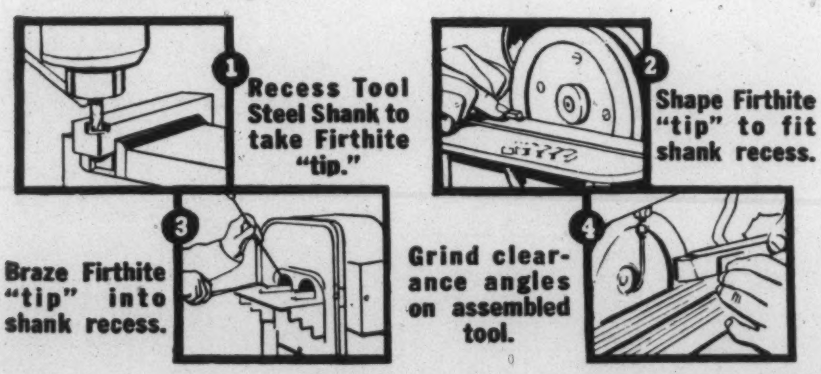


176 NEW STANDARD SIZES

for PROMPT DELIVERY at LOWER PRICES

MAKE YOUR OWN FIRTHITE CARBIDE TOOLS!

Don't slow up production for lack of enough Cutting Tools. Join the increasing group of manufacturers who make their own FIRTHITE Tools from Standard FIRTHITE Tips. Only FOUR basic steps are required to make these superior tools *in your own shop*. Information on request.


1 Recess Tool Steel Shank to take Firthite "tip."
2 Shape Firthite "tip" to fit shank recess.
3 Braze Firthite "tip" into shank recess.
4 Grind clearance angles on assembled tool.

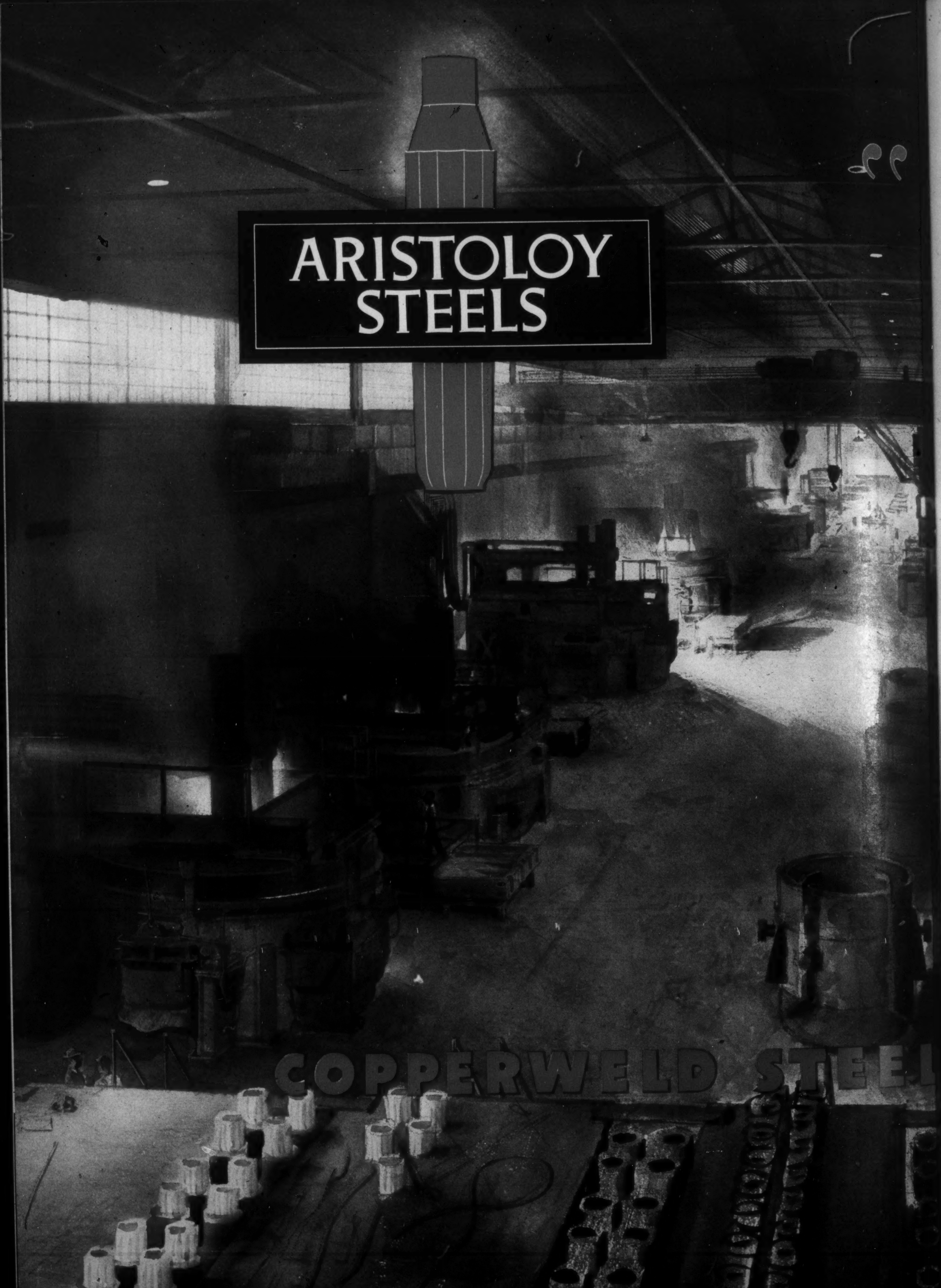
We have added 176 NEW Standard Sizes to the FIRTHITE line of Carbide TIPS for making your own Cutting Tools. Increased production facilities assure *prompt* delivery of all *standard* tips and special low prices. FIRTHITE Standard Tips now embrace almost the whole field of single point tool requirements and will fit a wide variety of special tools. Sizes range from 1/16"x5/32"x1/4" up to and including 1/2"x3/4"x1 1/4" in styles and grades to meet your needs.

Send for new STANDARD TOOL TIP Stock and Price List now!

FIRTH-STERLING STEEL COMPANY

OFFICE AND WORKS:
McKEESPORT, PA.
BRANCH WAREHOUSES:
NEW YORK CHICAGO
HARTFORD PHILADELPHIA
LOS ANGELES DAYTON
CLEVELAND DETROIT

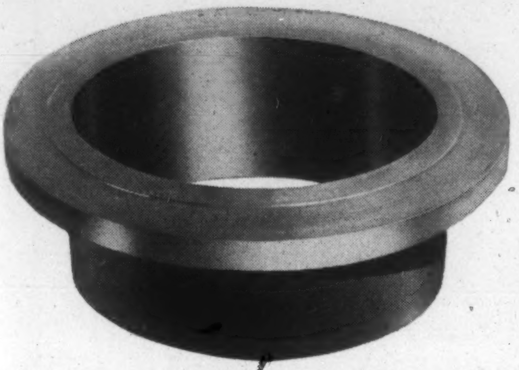
ARISTOLOY STEELS

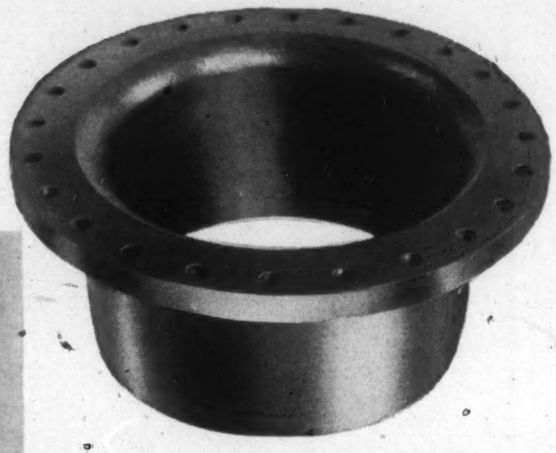


COPPERWELD STEEL

LENAPE A POLICY FOR ACTION

LENAPE'S contribution to the defense program is increased production to insure continuous, prompt flow of standard basic accessories for pressure vessels in marine, power, chemical and refinery applications—for which semi-processed and raw materials can be adequately stocked. This page presents the most active types which we offer for normal shipment.


Seamless Heavy Wall Welding Neck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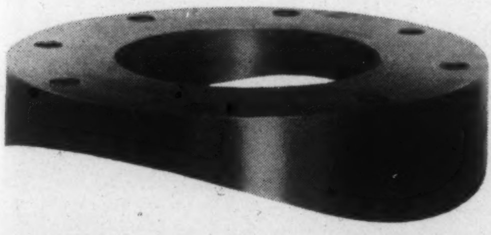
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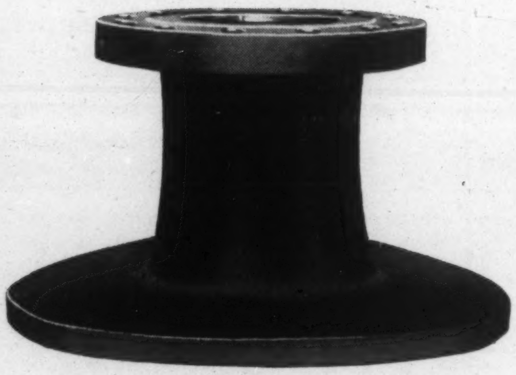
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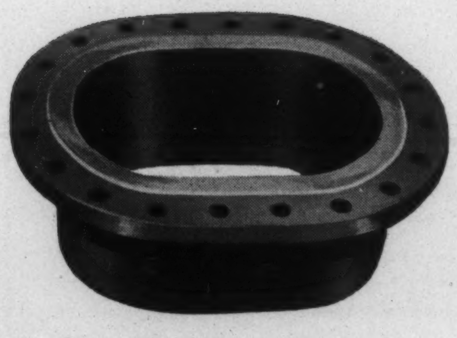
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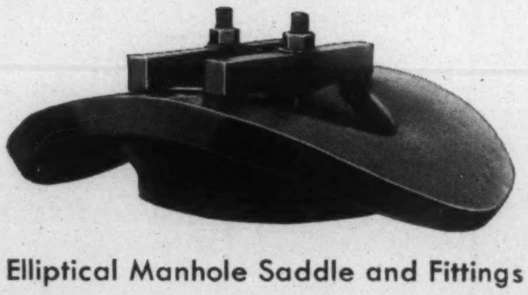
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Corroding (99.99+	no Bi)	60.0	5.00
Common (99.98+	no Bi)	63.7	5.18
Chemical (99.92+	.06% Cu)	80.9	6.14

*Rockwell "B" soft metal scale.
**Scratch-microcharacter method, all determinations at room temperature on cast specimens.

In general it might be said that within the limits covered by A.S.T.M. specifications, the hardness varies directly with increase in copper content and inversely as the bismuth content. Naturally the hardness decreases with the rise in temperature.

GRADE OF LEAD		TEMPERATURE 20° C	60° C	100° C	140° C
Corroding (99.99+	no Bi)	60	45	10	....
Chemical (99.92	.06 Cu)	85	80	70	45

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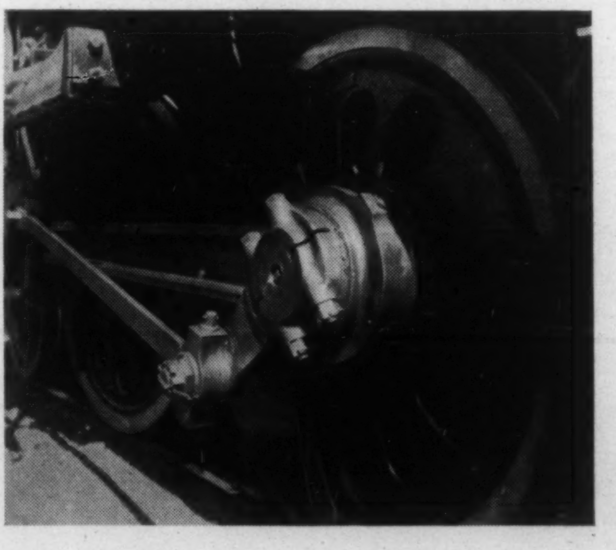

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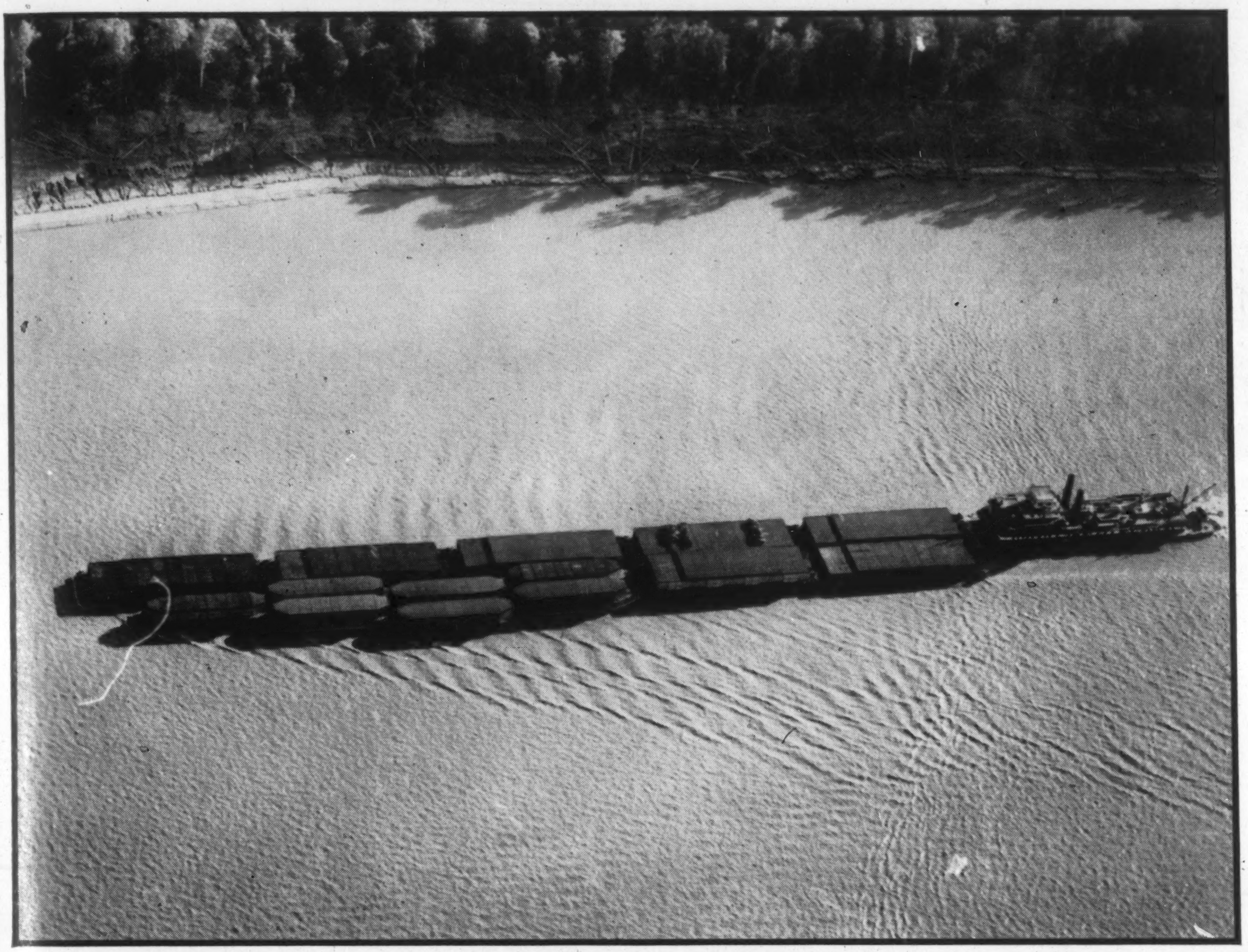

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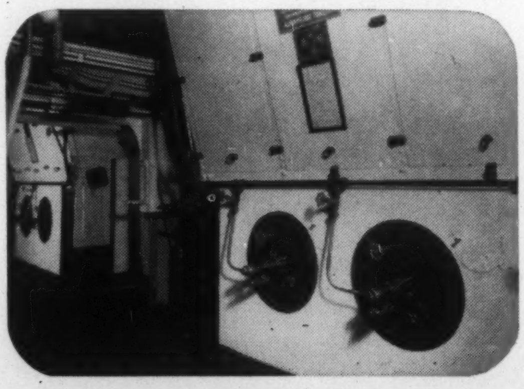

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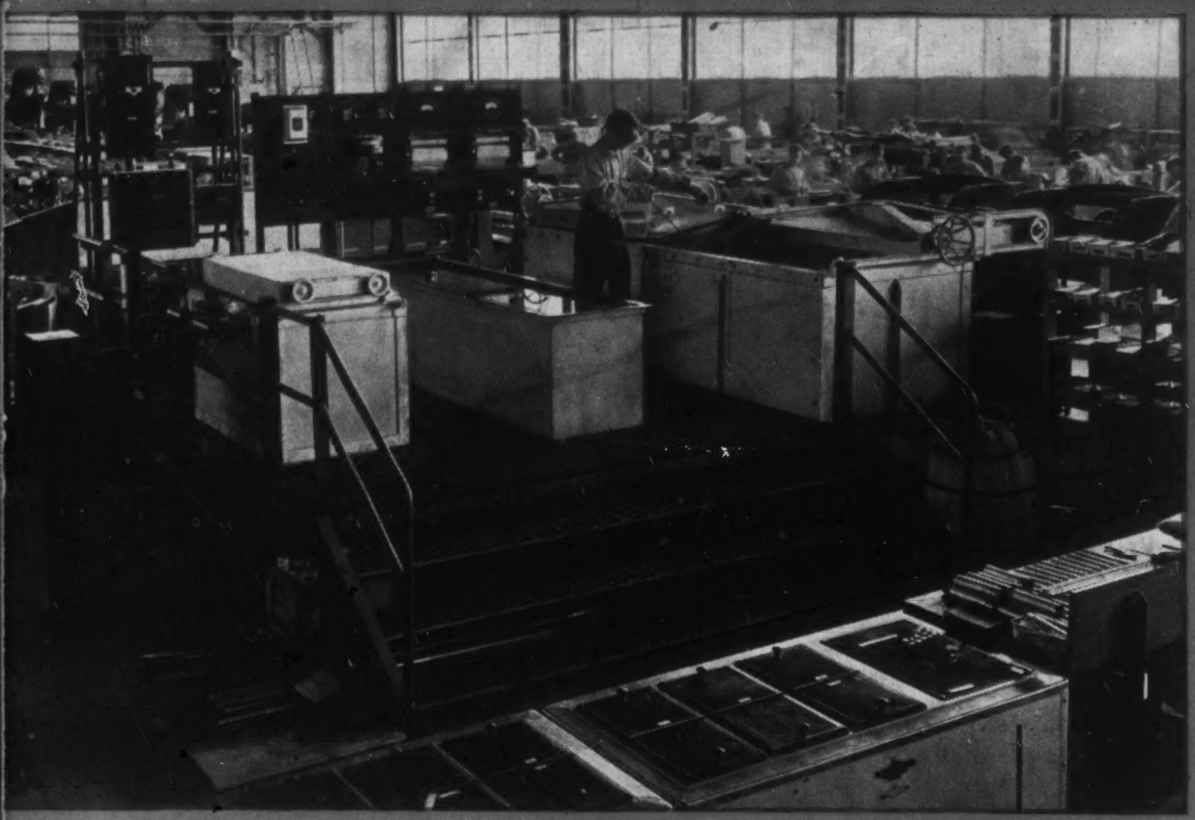

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